HELSINKI SCHOOL OF ECONOMICS (HSE)
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ESTIMATING SYSTEMATIC RISK IN THE PULP AND PAPER INDUSTRY

An application of the full-information approach

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PURPOSE OF THE STUDY

The objective of this thesis is the estimation of subindustry or product-line betas, the CAPM's measure of systematic risk, for the pulp and paper industry. The pulp and paper industry is a highly vertically integrated industry where the common pure-player approach to estimating industry betas is not applicable. To be able to estimate betas, the full-information (FI) approach first introduced by Fuller and Kerr (1981) is found to be the only applicable tool. The full-information approach makes use of a cross-sectional regression that is based on the insight that a firm's beta is the sum of its divisional betas. These divisional betas cannot be observed directly. However, by classifying firms' operations into defined subindustries and proxying for the value of each division with segment reporting data, it is possible to produce estimates of the subindustry betas.

DATA AND METHODOLOGY

The data in this study is comprised of the stock returns and IFRS business segment reporting data of 54 companies from the top 100 pulp and paper firms. The study period spans the years 1998 – 2006. Betas are estimated with the sum-beta adjustment using monthly returns. Leverage is accounted for by using two well-known models for unlevering betas. The studied product lines are: pulp, white papers, packaging, wood products and tissue papers. The models are tested for robustness against two potentially distorting variables: firm size and location. The main limitation of the study is its rather small sample size, which is constrained by both the amount of stock exchange listed pulp and paper companies and by whether they publish detailed enough segment reports.

RESULTS

The study shows that it is possible to successfully employ the full-information approach in a subindustry analysis by using detailed segment reporting data. All estimated models prove to be statistically significant. It is the first known FI-approach study to use IFRS segment reporting data, in particular EBITDA and assets by segment, to classify firm's operations into subindustries. Estimates of the betas for the studied subindustries of the pulp and paper industry are provided.

KEYWORDS

Cost of equity, divisional cost of capital, divisional beta, full-information approach, beta estimation, industry beta

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TUTKIELMAN TARKOITUS

Tutkimuksen tavoitteena on määrittää betat sellu- ja paperiteollisuuden eri sektoreille. Beta on CAP–mallin parametri systemaattiselle riskille. Sellu- ja paperiteollisuus on voimakkaasti vertikaalisesti integroitunut teollisuudenala, jossa yleisesti käytetty pure-player metodi ei ole hyödynnettävissä sektoribetojen määrittämiseen. Tässä viitekehyksessä soveltuu betojen estimointiin kuitenkin Fullerin ja Kerrin (1981) kehittämä nk. full-information (FI) metodi. Full-information metodi hyödyntää poikittaisregressiota, joka perustuu oivallukseen että koko yrityksen beta muodostuu summana yrityksen divisioonien betoista. Näitä divisioonakohtaisia betoja ei voida havaita suoraan. Luokittelemalla yritysten toiminnot sektoreihin ja hyödyntymällä segmenttiraportointia divisioonien arvon mittarina pystytään kuitenkin tuottamaan estimaatit sektoribetoille.

TIEDONLÄHTEET JA METODOLOGIA

Tutkimuksen otoksena toimii 54 yritystä sadan suurimman sellu- ja paperiteollisuuden yrityksen joukosta. Tutkimuksessa hyödynnetään näiden yritysten osaketuottoja sekä IFRS segmenttikohtaista raportointia. Tutkimus kattaa vuodet 1998 - 2006. Betat estimoidaan kuukausittaisella datalla käyttämällä ns. sum-beta korjausta. Velan vaikutus huomioidaan käyttämällä kahta tunnettua unlevering-mallia. Tutkitut sektorit ovat: sellu, paperit, pakkausteollisuus, puutuotteet ja pehmopaperit. Regressiomallien robustisuutta testataan kahta potentiaalisesti tuloksia vääristävää muuttujaa vasten: yrityksen kokoa ja sijaintia. Tutkimuksen pääasiallinen rajoite on otoksen koko, jota rajoittaa niin pörssilistattujen sellu- ja paperiyritysten määrä kuin näiden segmenttikohtaisen raportoinnin tarkkuus.

TULOKSET

Tutkimus osoittaa, että full-information metodia voidaan menestyksellisesti käyttää sektorikohtaisessa tutkimuksessa hyödyntämällä segmenttikohtaista raportointia. Kaikki estimoidut mallit osoittautuvat tilastollisesti merkitseviksi. Tämä on tiettävästi ensimmäinen FI-metodia käyttävä tutkimus, joka hyödyntämällä IFRS segmenttikohtaista raportointia, etenkin segmenttikohtaista EBITDA:aa sekä varallisuutta, klassifioi yritysten toimintoja sektoreittain. Tutkimus tuottaa estimaatit tutkittujen sellu- ja paperiteollisuuden sektoreiden betoille.

AVAINSANAT

Oman pääoman kustannus, divisioonakohtainen pääoman kustannus, divisioonakohtainen beta, full-information metodi, betan estimointi, sektoribeta

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1. Introduction

The cost of equity capital is a central theme in the finance literature, not least due to the important role it plays in practice, especially as a component of the total cost of capital. It is also an interesting topic because it acts as a link between corporate finance and capital market theories. The famous Capital Asset Pricing Model (CAPM) and its multifactor variations such as the Fama French Three Factor Model are the standard approach employed in the estimation of the cost of equity capital. The model's main parameter and measure of systematic risk, the CAPM beta, along with the equity risk premium are the most important variables that affect practitioners' estimates of the cost of equity. Having a good estimate for beta is of paramount importance as an incorrect beta leads to an incorrect cost of capital for potential investments which in turn results in a misallocation of capital between these investments and hence a loss of total value.

A recent survey (Brounen, de Jong and Koedijk, 2004) of the cost of capital practices of European firms suggests that simplistic methodologies of capital budgeting such as the payback method that does not take into account the time value of money are still heavily used in practice. However, at the same time firms increasingly place value on the use of discounted cash flow methods advocated by the finance literature and the related capital market models such as the CAPM and its extensions. Although these methods have existed for decades, their implementation continues to cause confusion. For example, practitioners have a hard time agreeing on the proper beta even for single listed companies as is evidenced by the substantially differing estimates of the numerous companies that calculate and publish betas (e.g. Bruner et al, 1998). These issues highlight the continuing importance of research that focuses on systematic risk and its more accurate estimation.

Even more controversial is the question of how to determine a beta to use for non-listed companies, new projects or at the divisional level of a company. I refer to the approaches developed to solve these problems as indirect methods, as opposed to the direct method where a beta of a listed asset is estimated to be use for that specific asset only. Different indirect methods have been suggested in the literature and these are presented in Section 4 of the thesis. This thesis focuses on the estimation of subindustry or product-line betas for the pulp and paper industry during a period from 1998 to 2006 using the so called full-information (FI) approach first suggested by Ehrhardt and Bhagwat (1991). The research is done as a project for Pöyry Forest Industry Consulting as part of an update to their cost of capital estimation methodology, which is the reason for the focus on the pulp and paper industry. The pulp and paper industry provides an interesting setting as it is a highly vertically integrated industry. This means that the vast majority of firms produce multiple products, and each firm with a different mixture. Due to this it is impossible to employ the common pure-play approach that focuses on comparable companies, because for almost any single company it is practically impossible to find peer companies with the exact same product mix. A potential solution to this problem is to classify the divisions of the companies into product lines, also known as product segments, and estimate betas for each product line using the full-information approach. The FI approach is a relatively new technique and to my best knowledge has not yet been applied in a subindustry analysis using segment reporting data at the level of detail attempted in this study. The approach is based on the principle of value additivity and its corollary: that the weighted average of a firm's divisional betas must add up to the total beta of the firm. A cross-sectional regression model, where the weights of each division as of the total value of the firm act as independent variables and each firm's beta as the dependent variable, is then estimated. The resulting coefficients are then interpreted as estimates of the product line betas. In this study, the effect of leverage is also taken into account by using two methods of unlevering the firm betas.

The study shows evidence that the full-information approach can indeed be successfully employed at this level of depth and provides estimates of the betas for the identified product lines of the pulp and paper industry. It contributes to the existing literature by showing evidence that using segment reporting data improves the full-information estimates. The main limitation of the study is its rather small sample that is constrained by both the number of stock exchange listed pulp and paper companies and their segment reporting standards. The sample used, however, is large enough to provide statistically significant estimates for all the regression models.

The rest of the paper is organized as follows: Sections 2 and 3 review the general theory behind the study while Section 4 provides a review of the literature on the indirect estimation of betas. This concludes the theory part of the thesis. The empirical part is structured as follows: first, in Section 5, the pulp and paper industry product lines used in the study are defined. Next, Section 6 describes the data and methodology used. Section 7 contains the model estimation, analysis and discussion of the results. Finally, in Section 8, conclusions are drawn.

2. The cost of capital

This section reviews the concept of the cost of capital and provides the primary theoretical background and motivation behind the study. Its aim is also to show how the specific research question of this paper fits into a larger framework. A review of the most important models for determining the cost of capital with a focus on current developments is provided.

2.1. Cost of capital and total cost of capital

The cost of capital is the rate at which future cash flows are discounted to their present value and due to this has a very fundamental role in valuation. It is also known as the required rate of return or discount rate. The cost of capital should reflect the risk of the cash flows being discounted. A riskier project should have a higher cost of capital than a less risky one. This reflects the basic theoretical intuition that risk and return should always go hand-in-hand (Bodie, Kane and Marcus, 2002, p.156).

Since companies are often financed with both debt and equity, a measure of the total cost of capital is typically needed. This is commonly achieved through the use of the weighted average cost of capital (WACC) measure, which is simply a weighted sum of the cost of debt and the cost of equity capital. The weights used are the proportions of debt and equity to total capital. Naturally, the next question is how to determine the cost of equity and cost of debt. As this study is focused on the cost of equity capital, the point of view is centered on it. However, capital market approaches can similarly be used to estimate the cost of debt.

2.2. Cost of equity capital and the Capital Asset Pricing Model

The cost of equity is the rate of return demanded by the shareholders of a company. It depends on both business risk and financial risk i.e. financial leverage. The effect of financial leverage, how capital structure affects the riskiness of the cash flows to equity holders and thus the required rate of return of equity capital, is discussed in the next section. The standard way of estimating the cost of equity is the application of the famous Capital Asset Pricing Model (CAPM) or one of its extensions. Another academic approach is the Arbitrage Pricing Theory (APT), which is however more difficult to implement due to the indeterminate number of risk factors it suggests and is thus not widely used in practice.

The key insight behind the CAPM is that total risk can be divided into unsystematic risk and systematic risk, a central finding of so called modern portfolio theory (MPT) developed by Harry Markowitz in the 1950's. Early theories of asset pricing suggested that the risk of an individual security is the standard deviation of its returns – a measure of return volatility. The larger the standard deviation of returns of a security the greater risk it carries. An investor's main concern, however, is the risk of his or her total wealth made up of a collection of securities, known as the portfolio. Markowitz pointed out that (i) when two risky assets are combined their standard deviations are not additive, provided the returns from the two assets are not perfectly positively correlated and (ii) when a portfolio of risky assets is formed, the standard deviation risk of the portfolio is less than the sum of standard deviations of its constituents. Markowitz was the first to develop a specific measure of portfolio risk and to derive the expected return and risk of a portfolio. Markowitz's model generates the efficient frontier of portfolios and the investors are expected to select a portfolio, which is most appropriate for them, from the efficient set of portfolios available to them. When analyzing the risk of an individual security, however, the individual security risk must be considered in relation to other securities in the portfolio. In particular, the risk of an individual security must be measured in terms of the extent to which it adds risk to the investor's portfolio. Thus, a security's contribution to portfolio risk is different from the risk of the individual security.

According to MPT then, unsystematic risk is the firm-specific component of total risk that can be diversified away by including more securities (assets) in a portfolio. However, the systematic or market risk of a security remains even after this. It is the component of total risk that cannot be diversified away. Systematic risk is influenced mainly by macroeconomic factors that affect different securities by a different magnitude.

The CAPM makes the following assumptions:

- All investors are price takers
- Perfect markets: no transaction costs, taxes, etc.
- Perfect information
- Existence of a risk-free asset which all investors can freely borrow or lend
- All investors have the same time horizon
- Each investor is solely concerned with the expected return and risk of his or her portfolio
- All investors are risk·averse

Under these assumptions, each investor wanting to hold risky assets will hold the so called market portfolio, a theoretical portfolio that includes all the possible tradable assets in the world. The equilibrium expected return of any security is then defined as follows:

$$r_i = r_f + \beta_i (r_m - r_f), \; (1)$$

where r is the expected return of security i, r_f is the expected risk-free rate and r_m is the expected return of the market portfolio. The factor (r_m-r_f) is known as the risk premium. In the case of equities this is the equity risk premium. β_i (beta) is the measure of systematic risk for security i and is defined as follows:

$$\beta_i = \frac{Cov(r_i, r_m)}{Var(r_m)}, \; (2)$$

where βi is the beta of security i, ri is the return of security i and r_m is the return of the market portfolio.

The beta of any asset is thus a correlation coefficient of its return with the market portfolio return. Individual betas are interpreted as follows: a beta of 1 means that the asset's return moves exactly in line with that of the market portfolio and is therefore as systematically risky as the market portfolio. A beta between 0 and 1 means that the asset's return reacts less sharply to changes in market return, implying lower systematic risk than that of the market portfolio. For an asset with a beta higher than 1 the opposite is true: it has higher systematic risk than the market portfolio. Finally, a beta below zero means that the asset's return is negatively correlated with that of the market i.e. it carries negative market risk, which is a rare situation.

2.3. Tests, extensions and critique of tests of the Capital Asset Pricing Model

Although the CAPM is a theoretically brilliant model and is widely used due to its intuitive simplicity, it has during its lifetime come under attack from different sides. One form of critique have been the findings of empirical studies that try to test whether the model works in practice. Many of these studies have not found a significant relationship between market risk (beta) and return in practice. There are two commonly used methods for testing the CAPM: cross-sectional tests and time-series tests. A cross-sectional test is performed as follows: first, a beta for each security is estimated over a certain time interval. Then, for each security, a CAPM equation that takes the estimated beta and the security's average return over the period as independent variables is written. These equations are then together run as a regression so that the estimated coefficient of the betas should equal the market portfolio's risk premium while the estimated intercept should give the risk-free rate. Time-series tests, by employing excess returns (the return in excess of the risk-free rate), check if a portfolio's prior beta explains its return under the condition that the intercept (the alpha) of the CAPM regression is zero. Both methods have mostly yielded mixed results for the validity of the basic CAPM. There exists a vast literature around the CAPM and this attempt to cover it is focused on a few important areas that researchers have ventured into during the roughly four decades of the model's existence: basic CAPM, CAPM with higher-order co-moments, conditional asset pricing models and CAPM conditional on time-varying volatility.

Early tests of the CAPM (Lintner, 1965; Douglas 1969) were primarily based on individual security returns. The empirical results of these showed virtually no support for the CAPM. Miller and Scholes (1972) pointed out some statistical problems with using individual securities. Since then, most studies have used portfolio returns to overcome these problems. Using portfolios constructed from NYSE stocks, Black, Jensen and Scholes (1972) showed a linear relationship between the average excess portfolio return and beta with a zero-beta version of the CAPM. Fama and McBeth (1973) extended the study and provided evidence of a larger intercept than the risk-free rate, that the linear relationship between the average return and beta holds and that this relationship holds well for longer data periods. However, subsequent studies such as those by Fama and French (1992), He and Ng (1994) and Davis (1994) provide weak evidence on the above relationships.

The mixed results of these studies on the return-beta relationship provoked further responses: Kothari, Shanken and Sloan (1995) remind about the survivorship bias in the data that is used for testing the validity of asset pricing model specifications. Also, many studies show that beta is unstable over time (Bos and Newbold (1984); Faff, Lee and Fry (1992); Faff and Brooks (1998)). Further, a number of papers highlight different model specification issues: Amihud, Christensen and Mendelson (1993) and Kim (1995) argue that errors in variables influence the empirical findings. Kan and Zhang (1999) focus on a time-varying risk premium, while Jagannathan and Wang (1996) show that specifying a broader market portfolio can affect the results.

The basic CAPM is implicitly based on the assumption that the distribution of returns is normal. As this is empirically known not to be true (e.g. Ané and Geman, 2000 and Chung, Johnson and Schill, 2006), researchers have started to look for ways to account for the third and fourth moments, skewness and kurtosis. The CAPM was extended to incorporate skewness by Kraus and Litzenberger (1976), Friend and Westerfield (1980), Sears and Wei (1985) and Faff, Ho and Zhang (1998) among others. However, these studies report mixed results. Harvey and Siddique (2000) examine an extension of the CAPM that includes conditional systematic co-skewness. Their results show that conditional skewness helps explain the cross-sectional variation of expected returns across assets and is significant even when factors based on size and book-to-market are included (see Section 2.4). Some studies have also shown that non-diversified skewness and kurtosis play a significant role in asset valuations: Fang and Lai's (1997) four-moment CAPM shows that systematic variance, systematic skewness and systematic kurtosis contribute to the risk premium of an asset while Christie-David and Chaudhry (2001) demonstrate that skewness and kurtosis explain the return-generating process in futures markets well.

The fact that beta is empirically known to be unstable over time led to the development of conditional asset pricing models. In a cross-sectional analysis of expected returns and beta, Fabozzi and Francis (1978) show that investors like to receive a positive premium for accepting downside risk, while a negative premium is associated with the up market beta. This was accomplished by defining a model with both a down (bear) market beta and an up (bull) market beta. The results suggest that downside risk may be a more appropriate measure of portfolio risk than the conventional beta. An extension by Kim and Zumwalt (1979) analyzed the variation of returns on securities and portfolios in up and down markets. Using three alternative methods to determine what constitutes an up and down market they also conclude that downside risk might be a better measure for portfolio risk. They defined an up market as either a month in which the market return exceeded the mean market return, the mean risk-free rate or zero. Chen (1982) allowed beta to be non-stationary while examining the risk-return relationship in up and down markets and concluded that under the condition of either constant or changing beta, investors seek compensation for downside risk, and again, that the down market beta is a more appropriate measure of portfolio risk.

A study by Ferson and Harvey (1991) on U.S. stock and bond returns, however, revealed that the time variation in the premium for beta risk appears to be more important than the changes in betas themselves. The reason behind this is the fact that equity risk premiums are found to vary with market conditions and the business cycle. E.g. Schwert (1989) shows that differing risk premia between up and down markets appear to be caused by varying systematic risk over the business cycle.

Pettengill, Sundaram and Mathur (1995) argued that the weak and intertemporally inconsistent results of studies testing for a relation between beta and return are due to the conditional nature of the relation between beta and the realized return. They pointed out that when realized returns are used, the relation between the beta and the expected return is conditional on excess market return. In their study of U.S. stocks over the period 1926 - 1990 they document the existence of a systematic conditional relation between beta and return for the total sample period as well as across sub-sample periods. Crombez and Vander Vennet (2000) performed the same analysis on the Brussels Stock Exchange over the period 1990 - 1996. They observed that beta is a strong and consistent indicator of both upward potential in bull markets and downside risk in bear markets. The results were robust for various definitions of beta and of up and down markets. Galagedera and Silvapulle (2002) adopted the approach of Pettengill et al. and examined higher-order systematic co-moments in the up and down markets. They postulated that the systematic risks corresponding to variance, skewness and kurtosis are different for up and down markets and found strong evidence that in presence of skewness in the market returns distribution the expected rate of return is related to both beta and systematic co-skewness.

After (general) autoregressive conditional heteroskedasticity ((G)ARCH) -type processes that model time-varying volatility were first introduced to finance theory by Engle (1982), researchers have developed asset pricing models that make use of them. The first study to model beta in terms of time-varying variance/covariance was made by Bollerslev, Engle and Woolridge in 1988. Fraser, Hamelink, Hoesli and MacGregor (2000) using monthly data from the U.K. market from 1975 to 1996, compared the cross-sectional risk-return relationship by using an unconditional specification of an asset's betas with betas obtained through two different types of (G)ARCH processes. They observed that the CAPM appears to hold better in downward moving markets than in upward markets and suggested that beta as a risk measure is more appropriate in bear markets. Further, they noted that their QTARCH (Quantitative Threshold ARCH, a type of ARCH process) specification, in which they allowed for skewness and kurtosis, yields a significant beta without having to account for up and down markets. In general, although not without exceptions, the ARCH-model-based empirical studies appear to provide stronger evidence of the risk-return relationship than the unconditional models.

At least two important universal forms of critique of tests of the CAPM exist: When testing the validity of the CAPM, researchers test versions of the equation given in (1). The CAPM is a single-period *ex ante* type of model. However, since it is not possible to observe *ex ante* returns, realized returns have to be used. It leads to the empirical question whether past returns conform to the CAPM. This provides ground for the common counterargument that these studies are limited to testing the link between realized risk and return, not expected risk and return as defined in the CAPM's assumptions. Of course, by this line of reasoning the CAPM is not testable at all. Another important counterargument against tests of the CAPM is the so called Roll's (1977) critique, which concerns the theoretical market portfolio of the CAPM that is typically proxied by some stock market index. Roll shows that the single-factor CAPM is rejected when the portfolio used as the market proxy is inefficient. Even very small deviations from efficiency can result in an insignificant relationship between risk and expected return (Roll and Ross, 1994). Since it is practically impossible for any market index to include all possible tradable assets, Roll's critique as well hypothesizes that the CAPM is untestable in practice. This has led researchers to find ways to approximate a more complete market portfolio. One form of such extensions are the consumption CAPMs (CCAPM) that rely on aggregate consumption. However, the findings from these studies raise further questions as they imply an improbably high risk aversion of investors for the models to work.

2.4. The Fama-French Three-Factor model

Among all multifactor asset pricing models, the Fama French Three Factor model has probably received the most attention since its invention. During the 1990s, the influential studies by Fama and French (1992, 1993, 1996) resulting in the Fama French Three Factor model (FF3F) that adds two 'risk factors' to the conventional beta presented a major setback for the CAPM's credibility, especially when the authors stated that "the CAPM beta is dead". In their most recent paper (2004) on the topic they maintain that "the CAPM's empirical problems probably invalidate its use in applications". The two risk factors capture the so called size and value effects, empirical phenomena that have been known for some time before the formulation of the FF3F model. In the model, the size effect is captured by the SMB (small minus big) factor and the value effect by the HML (high minus low) factor. The size effect first documented by Banz (1981) accounts for the fact that the stock returns of firms with a small market capitalization have tended to outperform the market. Firms with higher book-to-market ratios have also historically outperformed the market and this is known as the value effect. The results of the studies have basically implied that the size and value effects account for the majority of variation in cross-sectional return, whereas beta is only either a minor or even insignificant determinant of return. The FF3F model is able to explain over 90 % of the variation in return. The Fama & French studies are based on normal ordinary least squares (OLS) regressions i.e. on the assumptions that returns are normally distributed and that beta is stationary over time.

Although the FF3F model has been generally well received considering e.g. the amount of citations of the Fama & French papers and the fact that investors have invested significant sums into funds employing strategies based on the size and value effects (e.g. as of September 2007 over $150 billion invested in DFA funds, a company in which both Fama and French hold positions), some criticism has been voiced as well. The research that led to the FF3F model has previously been criticized as a form of 'data mining' (Black, 1993) as there is no theoretical framework behind it and the risk factors are based entirely on empirical observation. It has been shown that at least the size effect may only exist due to a survivalship bias in the data (Wang, 2000) and that it has largely disappeared since the early 1980's (Horowitz, Loughran and Savin, 2000) perhaps as markets have adapted since its discovery. Some authors have also noted that the atheoretical HML and SMB factors may act as proxies for other, possibly yet undiscovered risk factors, evidence being provided e.g. by Chung, Johnson and Schill (2006).

Recently, the FF3F model has even been termed as a logical fallacy due to the circular simultaneity that exists in the model (Coleman, 2006), although models of the type where a common factor appears in some form (e.g. share price, from which both return and size are derived) on both sides of the equation are not uncommon in empirical financial economics and this critique applies to all of them. Coleman's argument, in a nutshell, is the following: any equation that has the same variable or a transformation of the same variable on both of its sides is circular in nature and any reasoning based on this circularity is worthless. In Coleman's words: "models of return with price-, dividends- or shares-entailing risk factors, whether directly included through model specification or indirectly included through data sorting, are circular SES (single-equation-simultaneity) and thus fallacious, meaningless, non-interpretable, indeterminate and not scientifically valid". This critique of the FF3F model does not directly refute the empirical existence of the size and value effects which are widely documented, but it suggests that a statistical model based on these is misspecified and thus unscientific. Needless to say, this is a controversial issue and it remains to be seen how academia will deal with this in the future.

Whether the CAPM or the FF3F model is a better tool for measuring the cost of equity remains an open question. Nevertheless, even with the existence of further risk factors, it would be rather surprising if systematic or market risk, the risk that is nondiversifiable, would not remain the most important general factor in determining expected return (Brealey and Myers, 2003, p. 996). For this study, an estimation of the additional F&F factors is not performed, since the main motivation behind the study is to test whether significant differences in systematic risk exist between the product lines of pulp and paper firms and for this purpose no additional factors are needed.

2.5. Recent international evidence for versions of the CAPM

Most CAPM tests that follow the abovementioned Pettengill et al. procedure (1995) focus on the cross-sectional aspects of data. However, it may be more appropriate to examine the conditional relationship between beta and return by using time-series analysis, due to the well-known fact that beta is not stable over time. In Park's (2004) time-series-based study the conditional relationship between returns and betas is analyzed by using a Kalman filter technique, a special case of the general state-space model. He provides evidence from the U.S. stock market that there is a significant and systematic relationship between return and a Kalman filtered beta when the conditional nature of the CAPM is taken into account.

Smith (2006) shows that conditional coskewness is an important determinant of the returns to equity. Using French's data of 17 industry portfolios over the period from 1963 to 1997 he cannot reject a conditional three-moment CAPM. He also fits a conditional three-factor model in which the prices of factor risk vary through time and finds that adding SMB and HML, the size and book-to-market factors of Fama and French, has little impact on the price of market beta risk when coskewness risk is included in the model. Smith concludes that at least part of the ability of SMB and HML to explain returns is related to coskewness.

A recent paper likely to be influential is Ang and Chen's "CAPM over the long run: 1926 - 2001" (2007) where they show that a conditional single-factor model is able to account for the spread in the average returns of portfolios sorted by book-to-market ratios. They also note that the betas of portfolios sorted by book-to-market ratios vary over time and that in the presence of time-varying factor loadings OLS inference produces inconsistent estimates of conditional alphas and betas. This can be seen as direct critique of the Fama & French method as evidence is provided that the book-to-market effect is nonexistent when a conditional CAPM with a time-varying beta and market premium is employed.

2.6. Summary

The CAPM in its intuitive simplicity is the most widely used model for estimating the cost of equity. Its single parameter, the CAPM beta, is a measure of an asset's systematic risk. Empirical tests of the basic CAPM show mostly mixed results that do not support the theory. However, extensions of the basic CAPM that allow for non-normality in returns and time-varying factors have yielded positive results. At the same time, long existing arguments whether the CAPM is really testable at all have not been overthrown.

The CAPM's most prominent competitor, the Fama French Three Factor model, initially caused a noticeable blow to the CAPM's credibility. However, the FF3F model itself has received criticism and recent research seems to confirm that at least part of the explanatory power of the additional 'risk factors' is due to non-normality of returns or the fact that betas and the market risk premium are empirically observed to be time-varying. The quest for the best asset pricing model will most likely continue for some time and meanwhile practitioners will have to find compromises, in the same manner as they have done so far.

Returning back to the question of how to estimate the cost of equity, equation (1) can now be used to determine it by selecting a proxy for the risk-free rate (typically the returns of government bonds), selecting a proxy for the market portfolio (typically a broad stock market index) and calculating the beta of the stock against the market portfolio. As this study focuses only on the beta parameter, a more detailed discussion of the estimation of the other parameters of the CAPM is not included here. The next section explores how beta is estimated in more detail.

3. Estimation of beta and the effect of leverage

This section describes how the beta of exchange listed assets is typically estimated along with distinctions made for this study specifically.

3.1. Estimation of beta

The CAPM specification as in Equation (1) provides one way of estimating beta by regression. It requires the choice of a proxy for the risk free rate and the market return. Another more commonly used method in practice is the simple security market line specification:

$$r_i = \beta_i r_m, \quad (3)$$

where the parameters are defined as in Equation (1). In essence, this means that instead of calculating beta in terms of excess return as in Equation (1), it is calculated in terms of total return. This saves having to choose a proxy for the risk free rate. The most commonly used proxy for the risk free rate is the return of government bonds, typically those of the United States. However, when estimating betas for securities in an international sample, this choice seems harder to justify. Also, choosing a 'local' proxy for the risk free rate of the country or area each security is listed is not very compatible with the assumption of the CAPM that asks for a global market portfolio with all possible assets. In practice, betas calculated with either Equation (1) or (3) do not differ significantly (e.g. Ibbotson Associates, 2002, p. 92; Chua, Chang and Wu, 2006) and consequently most practitioners that publish betas calculate them via total return. For these reasons, especially because of having an international sample, the betas in this study are estimated in terms of total return.

The typical choice of estimation period interval and length in the cost of capital literature is the use of monthly return data for a period of five years, i.e. 60 monthly observations. The choice of a five year period is based on the findings of studies such as Gonedes' (1973) and Kim's (1993). This period length seems to represent an acceptable tradeoff between a sample that is large enough to enable reasonably efficient estimation and a short enough period over which a beta can be assumed to be stable. The most obvious reason for a change in a firm's beta over time is the change in the characteristics of the firms operations, especially due to mergers and acquisitions. The choice of monthly data as the best interval length is based on studies that test the effect of the use of different intervals on the efficiency of beta (e.g. Corhay, 1992).

3.2. Sum-beta adjustment

The idea behind the sum-beta adjustment was first introduced by Scholes and Williams (1977) and today it is a widely accepted method in correcting for nonsynchronous trading when estimating beta. The problem of nonsynchronous trading arises because prices are recorded at regular intervals although all assets do not trade at these intervals, which can induce bias in the beta estimates. This can especially be the case with small firm stocks and other securities that are traded infrequently. The idea is to use an additional lagged value of the market return in explaining the return of the security (Ibbotson, Kaplan and Peterson, 1997). In equation form with a total return specification this looks as follows:

$$r_{it} = \beta_{i0} r_{mt} + \beta_{i1} r_{mt-1} \quad (4)$$

The lagged and contemporaneous beta estimates are then added to obtain the estimate for the sum-beta: $\hat{\beta}_i = \hat{\beta}_{i0} + \hat{\beta}_{i1}$. Empirically, the sum-beta adjustment seems to correct for a significant part of the small firm i.e. size effect (Ibbotson Associates, 2002, p.109 and p. 128) by increasing the beta estimates for the smallest firms substantially while only marginally decreasing those for large and medium sized companies.

3.3. The effect of leverage: levered and unlevered beta

The effect that capital structure has on the riskiness of the cash flows to equity holders is known as financial leverage. The more debt a firm has, other things being equal, the more risky the cash flows to equity become and the higher the required rate of equity should be. The same applies for betas: as the equity beta measures the riskiness of the firm's equity, it is similarly affected by the firm's capital structure. A firm with a higher ratio of debt to total capital, other things being equal, should have a higher equity beta. Thus, to compare the betas of different businesses in terms of the riskiness of their operations i.e. the riskiness of the assets, the effect of capital structure should first be taken into account. This reasoning introduces the concepts of levered or equity beta and unlevered or asset beta. A levered beta describes the systematic risk of the equity of the firm, whereas the unlevered beta measures the systematic risk of the firm's assets.

This study uses two different methods for unlevering betas: the first method is the most commonly used in the finance industry. It is directly derived from the Miller-Modigliani (M&M) capital structure irrelevance theorem (Miller and Modigliani, 1958) which states that any choice of capital structure will not affect the value of the whole firm. Accordingly, the choice does not affect the required return on the firm's assets and the firm's asset beta. The key assumption behind the idea is that the sum of all future cash flows paid out to the debt and equity holders of the firm is unaffected by capital structure. The other assumptions are the existence of a perfect market i.e. a market with no transaction costs and no arbitrage opportunities. Also, corporate taxes are assumed not to exist. It depicts the following simple relationship between levered and unlevered beta:

$$\beta_a = \frac{\beta_e}{1 + D/E}, \quad (5)$$

where β_a is the unlevered or asset beta, β_e is the levered or equity beta and D/E is the debt-to-equity ratio of the firm.

The second method used is that of Hamada (1972), which is based on the M&M model, but also takes into account the existence of corporate taxes and the tax shields provided by debt:

$$\beta_a = \frac{\beta_e}{1 + (1 - t_c)(D/E)}, \quad (6)$$

where t_c is the marginal corporate tax rate and the rest of the variables defined as in Equation (5). Taxes matter, because interest payments on debt are tax deductible. To account for the effect of the tax shield, the following further assumptions are made in Hamada's model: the debt is assumed to be perpetual, default-free and to pay the risk-free rate. It is also assumed that the face value of the debt and the tax rate do not change over time. Grinblatt and

Titman (2002) point out that when a firm uses debt flexibly, the last assumption is easily violated. As a consequence from the above assumptions, the tax shield is also considered to be risk free and to be discounted at the risk-free rate. This assumption also may be violated when financing is flexible or when a firm is not able to fully take advantage of the tax shield e.g. due to the limited amount of years a loss is allowed to be carried forward for tax deductibility. In these cases a model that uses a higher discount rate than the risk-free rate to discount tax shields should obviously be preferred.

Another possibility when building this type of model is to assume that the firm maintains a fixed D/E ratio, that is, it issues or retires debt when the value of the firm changes as to keep the ratio stable. This dynamic updating of debt is captured in a model by Miles and Ezzell (1985). However, their model requires an estimate of the risk-free rate which adds a further parameter to the model. Grinblatt and Titman (2002) argue that for many firms the true unlevered return or beta lies somewhere between the results from the Hamada and Miles & Ezzell models due to the fact that many firms, although trying to maintain a fixed D/E ratio, make changes to their amount of debt rather slowly, presumably because of the costs associated with frequently issuing or repurchasing debt.

Both the M&M and Hamada methods assume a debt beta of zero, a simplifying assumption from reality. For example, a study by Booth (1999) shows a debt beta between 0.2 and 0.3 for the period 1970-1995 with U.S. data. However, including a debt beta would call for the estimation of this beta for each firm, which is not possible as only a small part of all debt securities are exchange listed. Another possibility would be to assume the same debt beta for each firm, a rather crude way of accounting for it. As the empirically observed debt betas are not very far from zero and a significant difference between unlevered equity betas calculated either with a common assumed debt beta or a debt beta of zero is not found e.g. by Chua, Chang and Wu (2006), a debt beta of zero is assumed when unlevering equity betas in this study.

4. Indirect methods for the estimation of beta

A direct estimation of beta is only possible if the entity is listed on an exchange so that its return can be calculated directly from the changes in its market price. In all other cases an indirect method has to be used. This section explores the approaches suggested by the finance literature.

4.1. The pure-play approach

The pure-play approach, first documented by Fuller and Kerr (1981), is the most common approach in the finance industry for estimating the beta of a non-traded firm or for a division. The term 'pure-player' refers to a firm that operates in a single line of business, and its beta can be used as an estimate of beta for this specific business or industry. The approach is simply based on calculating the average of the betas of pure-players in the same business and using the result as an estimate for the private company or division at hand. A very closely related approach is known as comparable company analysis (CCA), where the same method is employed except that the companies do not need to be pure-players but companies with similar enough risk profiles. However, in some cases the term 'comparable company' is also used to refer to a pure-player only. Using the more broadly defined CCA, it is even possible to include the market beta of a conglomerate in the estimation. This requires a careful analysis of the potential comparable companies to determine whether they actually are engaged in the same businesses or face the same risks and can therefore be rather subjective in nature.

Typically, after choosing the comparable companies, leverage is taken into account by first unlevering the betas of the comparable companies, taking their average and then relevering the result back to the target capital structure of the company the estimate is being calculated for. Bowman and Bush (2006) study the effectiveness of CCA with U.S. data of 480 companies and find that the method provides reasonably accurate estimates when the comparable companies are of similar size.

The pure-play method can only be applied when there are enough comparable companies available. This is clearly not the case in the highly integrated pulp and paper industry due to the differing product mixes among firms and thus a different approach is needed.

4.2. Accounting beta

In a similar way to estimating a market beta from the returns i.e. changes in the price of a listed security, it is possible to estimate an 'accounting beta' from the changes in a firm's earnings. This is relevant especially when the firm is a private company with no comparable listed companies available. An accounting beta measures the strength of the relationship between the firm's earnings and the aggregate earnings on all assets. This is basically equivalent to a real beta except that changes in accounting (book) earnings or cash flow are used in place of rates of return on securities. Beaver and Manegold (1975) provide evidence that accounting or cash-flow betas are highly positively correlated with stock market betas. However, the variation in accounting beta is known at best to explain only around 60 % of the variation in market beta, most studies suggesting a range between 20 to 40 % (e.g. Ball and Brown, 1969, and Karels and Sackley, 1993).

Damodaran (2000) comments on the problems of using accounting betas: "While the approach has some intuitive appeal, it suffers from three potential pitfalls. First, accounting earnings tend to be smoothed out relative to the underlying value of the company, resulting in betas that are 'biased down', especially for risky firms, or 'biased up', for safer firms. In other words, betas are likely to be closer to one for all firms using accounting data. Second, accounting earnings can be influenced by non-operating factors, such as changes in depreciation or inventory methods, and by allocations of corporate expenses at the divisional level. Finally, accounting earnings are measured, at most, once every quarter, and often only once every year, resulting in regressions with few observations and not much power."

A related method that makes use of the accounting beta is that proposed by Kulkarni, Powers and Shannon (1991). Their method's purpose is the determination of betas for business segments. Their procedure is to first compute segment accounting betas using divisional accounting data from firms that have comparable business lines to determine business segment betas. Because the weighted sum of the divisional accounting betas of a firm usually does not add up to either the total accounting beta or the market beta of the whole firm, each individual beta is then adjusted by the same constant so that the weighted average of divisional betas matches either the firm's overall accounting beta or preferably the marketbased measure of the firm beta. The resulting corrected figures are then used as estimates for segment betas. Naturally, this method suffers from the same problems as the normal accounting beta. The basic theoretical motivation behind the method, that a firm's total beta is a weighted average of the betas of its divisions, is the same as that of the full-information approach, which is discussed next.

4.3. The full-information approach

The full-information (FI) approach was first introduced by Ehrhardt and Bhagwat in 1991. Kaplan and Peterson (1998) later used the same technique to estimate industry betas and called it the Full Industry Beta or FIB –method. The underlying idea behind the full-information approach is that the observable beta of a firm engaged in multiple business segments is a weighted average of its unobservable business segment or divisional betas. This is based on the reasoning that the arbitrage-free market value of a firm is the sum of the values of its individual projects (e.g. Brealey and Myers, 2003, p. 178). The relationship for the case of betas can be expressed as follows:

$$\beta_{firm} = \sum_{i=1}^{n} \omega_i \beta_i, \quad (7)$$

where n is the number of divisions of the firm, β_{firm} is the beta of the firm, ω_i is the weight of division i as a proportion of the total value of the firm and β_i is the beta of division i.

To determine the betas of the lines of business, a cross-sectional regression model is estimated, where the dependent variable is the observable beta and the independent variables measure the participation of the firm in the different lines of business. The theoretically correct measure of participation would be each division's contribution to total market value, but since the individual divisions are not exchange traded so that their fair market value could be determined, divisional accounting figures such as earnings, sales and assets have to be used as proxies instead. Any other meaningful proxy for division value can also be used. The resulting estimates of the regression coefficients are then interpreted as the betas of each line of business. The approach has been employed both to calculate industry betas (e.g. Kaplan and Peterson, 1998) with the use of data that includes conglomerates as well as to determine subindustry or product-line betas e.g. in two recent papers dealing with the insurance industry (Cummins and Phillips, 2005; Natale, 2005).

The basic ordinary least squares (OLS) version (Ehrhardt and Bhagwat, 1991) is estimated with the following regression:

$$\beta_j = \sum_{i=1}^{n} \beta full_i \omega_{ji} + \upsilon_j, \quad (8)$$

where n is the number of product lines or industries, ω_{ij} is the weight of firm j in product line or industry i, the $\beta full_i$s are the regression coefficients to be estimated and υ_j is the error term.

Kaplan and Peterson (1998) suggest a modified version of the model, where the observed betas are weighted by the market capitalization of each company, thus transforming it into a weighted least squares (WLS) regression. Their motivation for this is the observation that the CAPM beta and market capitalization are known to be negatively correlated (e.g. Chan and Chen, 1988; Ibbotson, Kaplan and Peterson, 1997).

An interesting, although not too surprising finding of the studies mentioned above is that industry betas and hence the cost of equity capital are higher when calculated using only pure-players than when also including conglomerates as can be done with the full-information approach. This is due to the fact that the pure-player approach is limited to firms operating in a single line of business and these firms tend to be smaller firms. In other words, industry betas and thus the estimates for the cost of equity capital are biased upwards when conglomerates are excluded from the analysis. In this sense, the full-information approach can be seen as superior to the pure-play approach. However, implementing the FI approach calls for a considerably larger sample than with the pure-player approach as well as the classification of the firms' divisions into common product segments, which requires an extensive amount of manual effort, especially when this is not performed with preexisting classifications with pre-coded segment data. The known earlier studies, with the possible exception of Natale (2005), all use preexisting classifications and pre-coded segment sales data. The effort needed in its implementation is most likely the reason why the FI approach, since its invention, has not appeared much in academic research until very recently such as in the papers mentioned above.

4.4. Summary

This section presents three methods documented in the finance literature for the indirect estimation of betas. The pure-play approach is the most commonly used method and it simply involves taking an average of the betas of identified pure-players or comparable companies. The full-information approach is a method for determining product segment betas using a cross-sectional regression. In practical terms, the FI approach can be thought of as a statistical model that requires a larger sample while the pure-play approach is usually performed by selecting just a few of the best matching peer companies. The third method, the accounting beta, is used to determine a form of beta from accounting data only. It is sensible to use only for non-listed companies when no comparable listed companies are available as there are some major drawbacks related to its usefulness.

From the identified methods, the full-information approach is best suited for the environment of the pulp and paper industry and is therefore chosen as the methodology for this study.

5. Product line classification

5.1. Segment reporting

The study of the divisional financial results of firms in an international context has been possible since International Accounting Standard (IAS) 14 'Segment Reporting' was first introduced in the beginning of the 80's. Its current form came into effect in 1998 and it establishes principles for reporting financial information by line of business and by geographical area. It is applicable for companies with publicly traded debt or equity or companies that are in the process of issuing them. The basic rule for whether a company is required to report a certain business as an individual division is when 10 % or more of the firm's total sales or profits are generated by this business or when 10 % or more of the firm's total assets are used by this business. IAS 14 will be replaced by IFRS 8 'Operating Segments' in 2009. The wide availability of segment reporting statements through the annual reports of companies make a divisional analysis such as the full-information approach possible.

5.2. Pulp and paper industry product line classification

To be able to employ the full-information approach, common product lines have to be defined first. The product line classification is based on (and limited by) the manner in which pulp and paper companies report their results. The classification made by the companies for their reporting purposes is primarily based on the end use (or use by the next level in the value chain) of the products. The product-line classification of this study defines the following five categories:

- Pulp: market pulp i.e. pulp sold to the market
- White: 'white papers', includes publishing papers (newsprint and magazine) and fine papers (printing and writing)
- Packaging: packaging paper, carton board, etc.
- Tissue: tissue products such as towels, diapers etc.
- Wood products: engineered wood such as plywood, veneer, etc.

In addition to the above categories a sixth category, 'Other', is also needed for the regression model specification. As its name implies, this category includes all the operations that do not fit the above categories. Based on the segment reports of the firms studied, it would be possible to further identify a few categories, including wood supply and specialty papers as well as a split of white papers into publishing and fine papers, but this would add more independent variables to the regression model, which is not desirable due to the relatively small sample size of the study (see Section 6.3).

6. Data

6.1. Sample selection

The initial sample consists of the top one hundred pulp and paper companies of the year 2005, a list that is published yearly in the Pulp & Paper International magazine (RISI, 2006). The list is compiled by ranking firms based on their amount of sales of pulp and paper products. From this list, I first take all 73 stock-exchange listed firms that were listed as of January 1st, 2007 with at least four years of market price history available. I also include Georgia-Pacific which was delisted end of 2005, as well as two firms just outside the top 100: Rottneros and Neenah Paper. Of these, I select all firms that perform segment reporting on a level detailed enough to assign their divisions to product-line segments. Companies with insufficient reporting detail are thus dropped from the sample. In spite of IAS 14, due to differing conventions in reporting most of the firms with no detailed segment reporting are firms that operate outside the Western countries, e.g. only two of a total of seventeen Asian firms in the initial sample perform detailed segment reporting. Four companies that manufacture solely specialty paper products are excluded from the sample as they do not fit the product line classification under Section 5.2. This leaves me with a final sample of 54 companies for the period 2003-2006; these constitute the sample for the second subperiod. Of these, I then take all 47 companies that were also listed during 1998-2002 to get the sample for the first subperiod. Accordingly, these same 47 firms also provide the sample for the whole period of 1998-2006. A geographic breakdown of the final 2003-2006 sample is shown in Table 1: 50 % of the companies operate mainly in North America (the United States and Canada) and roughly 30 % mainly in Europe.

The choice of sample period and subperiods is made due to the following reasons: first, after the current IAS 14 came into effect in 1997, 1998 was the first year where segment reporting was widely performed and virtually no segment reports are available prior to this. Second, although as described in Section 3.1, the best beta estimates are achieved with 60 monthly observations and this has since become the most widely used period length in most studies as well as in practice, betas are known to be changing over time (see Section 3.1.) and with the business cycle (e.g. Stremme and Basu, 2007). This is a clear drawback in the use of a static beta and also suggests that it may make sense to have data worth the whole length of a business cycle as to produce an average beta over this period. Since the business cycles of pulp and paper products are considerably longer than 5 years, and with the hope of capturing a whole cycle, I take as long a period as available, 1998-2006 i.e. nine years, and then divide this into two subperiods for separate study: one of five and one of four years.

Table 1
Geographic breakdown of sample by main operating area 2003-2006

Area	**No. of firms**
North America	27
Europe	16
Latin America	5
Africa	2
Asia	2
Australia	2
Total	54

To sum up, I have now constructed three samples, one for the whole period of 1998-2006 (nine years or 108 months) and one for each subperiod: 1998-2002 (five years or 60 months) and 2003-2006 (four years or 48 months). Tables 2, 3 and 4 present the three samples with the calculated betas and other parameters as described in the next section.

Table 2
Listed pulp and paper companies with detailed segment reporting
Period: 1998-2002

	Levered	Unlevered					
Company	Raw beta	M&M no tax	Hamada	D/E	Tax rate	Market cap.	PPI Rank
International Paper Company	0.50	0.30	0.32	68%	18%	18586	1
Stora Enso Oyj	1.58	0.97	1.12	63%	34%	10320	2
Svenska Cellulosa AB	0.94	0.63	0.70	49%	30%	6016	3
Procter & Gamble Company	0.13	0.12	0.12	10%	35%	116694	4
Georgia Pacific	2.17	0.77	1.03	183%	40%	6175	5
Kimberly-Clark Corp.	0.55	0.49	0.51	11%	31%	31565	7
UPM-Kymmene Corp.	1.21	0.77	0.86	58%	29%	8670	8
Weyerhaeuser Company Limited	1.04	0.64	0.75	63%	38%	12050	9
Smurfit-Stone Container Corp.	1.43	0.60	0.85	138%	51%	4007	11
M-Real Corp.	1.16	0.38	0.47	208%	30%	1293	13
Paperlinx Limited	0.60	0.39	0.42	53%	21%	677	14
Meadwestvaco Corp.	1.03	0.63	0.74	63%	36%	3731	15
Amcor Limited	0.43	0.29	0.32	45%	29%	2908	18
Sappi Limited	1.32	0.54	0.62	144%	22%	1860	19
Abitibi-Consolidated Inc	1.39	0.70	0.83	99%	32%	2921	20
Norske Skogindustrier	1.73	0.78	0.93	121%	29%	1900	21
Domtar Inc	1.09	0.67	0.75	61%	28%	1877	22
Rengo Company Limited	0.86	0.27	0.48	216%	63%	731	24
Bowater Inc	1.21	0.68	0.97	77%	69%	2592	25
Cascades Inc	0.02	0.01	0.01	171%	36%	486	27
Temple Inland Inc	0.99	0.33	0.44	203%	38%	2944	28
Empresas CMPC SA	0.83	0.56	0.60	47%	17%	1763	34
Tembec Inc	0.97	0.36	0.49	172%	42%	580	36
Mayr-Melnhof Karton AG	0.82	0.59	0.64	39%	27%	605	37
Holmen AB	1.27	1.05	1.08	21%	17%	2252	39
Rock Tenn	0.59	0.27	0.34	120%	40%	460	42
Smith (DS) PLC	1.10	0.78	0.86	41%	31%	808	43
Catalyst Paper Corp.	1.20	0.89	0.96	36%	29%	1175	44
Aracruz Celulose SA	1.43	0.83	0.91	72%	22%	1712	45
Portucel Empresa	0.80	0.49	0.55	64%	31%	700	46
Nampak Limited	0.68	0.56	0.59	22%	28%	843	51
Suzano Papel E Celulose SA	1.05	0.31		240%		323	52
Votorantim Celulose Papel SA	1.59	0.83	0.95	92%	25%	1167	53
Wausau Paper Corp.	0.56	0.42	0.47	33%	37%	655	55
Potlatch Corp.	0.83	0.45	0.54	84%	37%	965	64
West Fraser Timber	1.28	0.78	0.94	64%	43%	672	66
Caraustar Industries	0.90	0.36	0.52	152%	52%	404	70
Canfor	1.82	0.82	1.06	121%	41%	522	72
Longview Fibre Company	0.58	0.30	0.36	91%	36%	601	75
Cheng Loong Company Limited	0.24	0.12	0.13	104%	18%	238	78
Mercer International Inc	1.11	0.33	0.33	238%	2%	107	79
Gascogne	0.51	0.28	0.34	87%	40%	144	81
Greif Inc	0.84	0.51	0.60	66%	38%	649	84
Grupo Empresarial ENCE	1.06	0.68	0.75	56%	24%	367	91
Otor	1.20	0.31	0.41	289%	34%	60	93
Pope & Talbot Inc	0.93	0.48	0.61	95%	45%	205	98
Rottneros	1.07	1.03	1.03	4%	23%	173	
Average	0.99	0.54	0.64	97%	33%	5450	
Standard Deviation	0.43	0.25	0.28	68%	12%	17483	
Min	0.02	0.01	0.01	4%	2%	60	
Max	2.17	1.05	1.12	289%	69%	116694	

Notes: 'Raw beta' denotes market beta calculated with the sum-beta adjustment, 'M&M no tax' denotes the unlevered beta calculated with the Miller-Modigliani assumptions, 'Hamada' denotes the unlevered beta calculated with the Hamada adjustment, 'D/E' denotes the debt-to-equity ratio, 'Tax rate' denotes the effective company tax rate and 'Market cap.' denotes the market capitalization. The three figures mentioned last are calculated as averages over the five years from 1998-2002. The last column 'PPI Rank' denotes the rank of each company in the ranking of the PPI magazine for the year 2005. For companies with no effective tax rate available, the Hamada-type beta could not be calculated.

Table 3
Listed pulp and paper companies with detailed segment reporting
Period: 2003-2006

	Levered	Unlevered					
Company	Raw beta	M&M no tax	Hamada	D/E	Tax rate	Market cap.	PPI Rank
International Paper Company	1.00	0.60	0.72	67%	43%	18295	1
Stora Enso Oyj	1.24	0.80	0.85	56%	16%	11744	2
Svenska Cellulosa AB	1.12	0.76	0.82	47%	24%	10104	3
Procter & Gamble Company	0.24	0.21	0.22	15%	31%	154277	4
Georgia Pacific	1.76	1.06	1.21	67%	32%	8695	5
Kimberly-Clark Corp.	0.62	0.54	0.56	14%	23%	30112	7
UPM-Kymmene Corp.	1.48	0.97	1.05	52%	21%	11264	8
Weyerhaeuser Company Limited	1.02	0.62	0.75	64%	43%	15870	9
Smurfit-Stone Container Corp.	1.81	0.84		115%		3927	11
M-Real Corp.	1.97	0.73		168%		1847	13
Paperlinx Limited	0.45	0.26	0.29	74%	26%	1207	14
Meadwestvaco Corp.	0.87	0.56	0.58	55%	8%	5862	15
Amcor Limited	0.56	0.39	0.41	46%	22%	4455	18
Sappi Limited	1.05	0.61	0.64	73%	12%	2934	19
Abitibi-Consolidated Inc	2.13	0.76		180%		2363	20
Norske Skogindustrier	1.74	0.87	1.14	100%	47%	2913	21
Domtar Inc	1.01	0.54	0.61	88%	28%	2229	22
Rengo Company Limited	1.13	0.39	0.56	193%	47%	1145	24
Bowater Inc	1.67	0.73		128%		2054	25
Cascades Inc	0.52	0.22	0.24	131%	15%	880	27
Temple Inland Inc	1.84	0.68	0.86	171%	34%	4265	28
Sonoco Products Company	0.93	0.74	0.79	27%	34%	3022	30
Graphic Packaging Corp.	-0.59	-0.16		267%		889	31
Empresas CMPC SA	0.55	0.45	0.46	23%	16%	5109	34
Packaging Corp. Of America	0.57	0.44	0.49	29%	38%	2380	35
Tembec Inc	1.84	0.23	0.41	684%	49%	351	36
Mayr-Melnhof Karton AG	0.62	0.55	0.57	14%	31%	1700	37
Holmen AB	1.40	1.14	1.20	23%	29%	3065	39
Rock Tenn	1.51	0.72	0.80	110%	20%	665	42
Smith (DS) PLC	1.12	0.75	0.87	50%	43%	1050	43
Catalyst Paper Corp.	1.80	0.86		110%		647	44
Aracruz Celulose SA	0.82	0.60	0.63	37%	21%	4539	45
Portucel Empresa	0.42	0.24	0.27	73%	21%	1699	46
Nampak Limited	1.16	0.97	1.04	19%	38%	1433	51
Suzano Papel E Celulose SA	0.85	0.47	0.53	79%	25%	1681	52
Votorantim Celulose Papel SA	0.76	0.50	0.51	54%	8%	2972	53
Klabin SA	0.87	0.60	0.63	46%	13%	1744	54
Wausau Paper Corp.	1.54	1.26	1.35	22%	37%	746	55
Billerud AB	0.80	0.60	0.65	34%	29%	829	63
Potlatch Corp.	2.01	1.53	1.67	32%	35%	1416	64
West Fraser Timber	0.70	0.51	0.55	38%	26%	1458	66
Caraustar Industries	2.79	1.17	1.50	138%	38%	340	70
Canfor	0.79	0.53	0.56	49%	19%	1385	72
Longview Fibre Company	1.47	0.96	1.11	53%	38%	1016	75
Cheng Loong Company Limited	1.34	0.79	0.84	69%	15%	368	78
Mercer International Inc	1.43	0.23	0.37	525%	45%	246	79
Gascogne	0.26	0.12	0.18	110%	62%	164	81
Greif Inc	1.84	1.29	1.41	43%	29%	1583	84
VPK Packaging	0.35	0.28	0.29	24%	17%	308	89
Grupo Empresarial ENCE	0.88	0.62	0.67	40%	24%	1058	91
Otor	-0.04	-0.01	-0.02	193%	41%	113	93
Pope & Talbot Inc	1.78	0.60	0.70	195%	21%	195	98
Rottneros	1.11	0.88	0.93	26%	26%	189	
Neenah Paper	1.15	0.75	0.87	52%	38%	473	
Average	1.11	0.64	0.72	96%	29%	6320	
Standard Deviation	0.62	0.33	0.36	117%	12%	21198	
Min	-0.59	-0.16	-0.02	14%	8%	113	
Max	2.79	1.53	1.67	684%	62%	154277	

Notes: see Table 2

Table 4
Listed pulp and paper companies with detailed segment reporting
Period: 1998-2006

Company	Levered Raw beta	Unlevered M&M no tax	Unlevered Hamada	D/E	Tax rate	Market cap.	PPI Rank
International Paper Company	0.56	0.33	0.37	68%	28%	18457	1
Stora Enso Oyj	1.42	0.89	1.00	60%	28%	10953	2
Svenska Cellulosa AB	0.90	0.61	0.66	48%	27%	7833	3
Procter & Gamble Company	0.14	0.13	0.13	12%	33%	133398	4
Georgia Pacific	2.08	0.79	1.03	163%	37%	6895	5
Kimberly-Clark Corp.	0.55	0.49	0.50	13%	28%	30919	7
UPM-Kymmene Corp.	1.18	0.76	0.84	56%	27%	9823	8
Weyerhaeuser Company Limited	1.00	0.61	0.72	63%	40%	13747	9
Smurfit-Stone Container Corp.	1.38	0.60	0.85	128%	51%	3971	11
M-Real Corp.	1.18	0.41	0.51	190%	30%	1540	13
Paperlinx Limited	0.25	0.15	0.16	65%	23%	980	14
Meadwestvaco Corp.	0.96	0.61	0.67	59%	25%	4678	15
Amcor Limited	0.40	0.27	0.30	46%	26%	3595	18
Sappi Limited	1.06	0.50	0.56	112%	20%	2337	19
Abitibi-Consolidated Inc	1.41	0.60	0.74	135%	32%	2673	20
Norske Skogindustrier	1.66	0.79	0.95	112%	32%	2350	21
Domtar Inc	0.97	0.56	0.63	73%	28%	2034	22
Rengo Company Limited	0.95	0.31	0.50	206%	57%	915	24
Bowater Inc	1.18	0.59	0.90	100%	69%	2353	25
Cascades Inc	0.07	0.03	0.03	154%	30%	661	27
Temple Inland Inc	1.13	0.39	0.51	189%	37%	3531	28
Empresas CMPC SA	0.76	0.56	0.59	36%	17%	3250	34
Tembec Inc	1.01	0.20	0.31	399%	44%	478	36
Mayr-Melnhof Karton AG	0.76	0.60	0.64	28%	29%	1092	37
Holmen AB	1.21	1.00	1.04	22%	23%	2613	39
Rock Tenn	0.76	0.35	0.43	116%	32%	551	42
Smith (DS) PLC	1.07	0.73	0.83	45%	37%	915	43
Catalyst Paper Corp.	1.29	0.77	0.87	69%	29%	940	44
Aracruz Celulose SA	1.13	0.72	0.78	56%	21%	2969	45
Portucel Empresa	0.74	0.44	0.50	68%	28%	1144	46
Nampak Limited	0.76	0.63	0.67	21%	33%	1105	51
Suzano Papel E Celulose SA	0.95	0.35	0.42	168%	25%	926	52
Votorantim Celulose Papel SA	1.26	0.72	0.78	75%	17%	1969	53
Wausau Paper Corp.	0.73	0.57	0.62	28%	37%	695	55
Potlatch Corp.	1.04	0.65	0.75	61%	36%	1166	64
West Fraser Timber	1.10	0.72	0.83	52%	37%	1021	66
Caraustar Industries	1.22	0.50	0.70	146%	48%	375	70
Canfor	1.54	0.81	0.94	89%	28%	906	72
Longview Fibre Company	0.89	0.51	0.61	73%	37%	785	75
Cheng Loong Company Limited	0.49	0.26	0.28	88%	16%	296	78
Mercer International Inc	1.20	0.26	0.29	366%	16%	168	79
Gascogne	0.55	0.28	0.36	97%	42%	153	81
Greif Inc	1.09	0.70	0.79	56%	34%	1064	84
Grupo Empresarial ENCE	1.02	0.68	0.74	49%	24%	674	91
Otor	1.04	0.30	0.40	253%	36%	83	93
Pope & Talbot Inc	0.97	0.41	0.50	139%	33%	200	98
Rottneros	0.98	0.86	0.88	14%	24%	180	
Average	0.98	0.53	0.62	99%	32%	6157	
Standard Deviation	0.38	0.22	0.25	82%	10%	19761	
Min	0.07	0.03	0.03	12%	16%	83	
Max	2.08	1.00	1.04	399%	69%	133398	

Notes: 'Raw beta' denotes market beta calculated with the sum-beta adjustment, 'M&M no tax' denotes the unlevered beta calculated with the Miller-Modigliani assumptions, 'Hamada' denotes the unlevered beta calculated with the Hamada adjustment, 'D/E' denotes the debt-to-equity ratio, 'Tax rate' denotes the effective company tax rate and 'Market cap.' denotes the market capitalization. The three figures mentioned last are calculated as averages over the nine years from 1998-2006. The last column 'PPI Rank' denotes the rank of each company in the ranking of the PPI magazine for the year 2005.

6.2. Data

The market data for the study are obtained from the Datastream database. For each of the firms in the sample, the monthly total stock market return and the yearly end-of-year market capitalization for the whole period from January, 1998 to January, 2007 are retrieved. I also retrieve the monthly return for the MSCI World total return index for the same period to be used as the market proxy. From the Worldscope database, I obtain figures for book-value-based total debt and yearly effective tax rates for the above period. Both market capitalization and total debt are measured in U.S. dollars; they are available in the databases with conversions at yearly average exchange rates when necessary. The yearly debt-to-equity (D/E) ratio is then calculated by dividing total debt by market capitalization. The effective tax rate is based on reported actual taxes paid divided by profit before taxes and is only available for the years in which a firm had taxable earnings to declare. Thus, for many firms, an effective tax rate is unfortunately only available for one or two years of the respective period or not at all, which renders the Hamada-type beta estimate based on these less reliable. For each of the three study periods, I then average over the yearly figures for the D/E -ratio, the effective tax rate and market capitalization.

Next, raw market betas with the sum-beta adjustment as in Equation (4) and without it as in Equation (3) are calculated for the sample firms for the three periods. I then perform a pair wise t-test to check whether betas calculated either with or without the adjustment differ significantly. Since the difference is not significant (see Table 17 in the Appendix), I proceed using only the sum-beta adjusted measures. These betas are then unlevered with the methods presented in Equations (5) and (6). The MSCI World index is chosen as the market portfolio as it is probably the widest available equity index to approximate a world equity portfolio. The use of one global vs. a local market portfolio for each market is also much more compatible with the assumptions of the CAPM. Although no formal test is made, the produced betas, with a focus on the firms outside Europe and the U.S., are compared with published betas calculated against local equity indexes and the differences are noted to be minor.

The resulting figures are presented in Table 2, 3 and 4 along with descriptive statistics.

The accounting data required for the calculation of the segment weights are obtained from the Reuters Knowledge database. These data come from the segment reports of the companies' audited annual or interim reports. The database offers the newest restated results by default and this is also chosen as the methodology for this study. For each firm, segmented total (net) sales, earnings before interest and taxes (EBIT), depreciation and amortization (D&A) and total assets are retrieved for the nine years from 1998 to 2006. Earnings before interest, taxes, depreciation and amortization (EBITDA), if not available, is then manually calculated by adding D&A to EBIT. Data that is missing from the database is obtained manually from the annual reports of the respective company. When this is the case, the newest data is used, i.e. if results have been restated, the newest available figures are used.

Next, the actual segment classification is performed as follows: first, each division is analyzed and matched to one of the product lines defined in Section 5.2. Only divisions with over 85 % of sales from the matching product line get assigned to it. Divisions with operations outside the classification scheme get assigned to the 'Other' -category. Possible supporting functions (e.g. headquarters) that are reported as a separate division are assigned to the product lines according to each product line's weight, which is achieved simply by disregarding their figures. Second, yearly participation ratios are calculated for each product line by dividing each line's yearly figure for sales, EBITDA and assets by the total figure, i.e. the sum of the product lines. Last, an average of the yearly weights over the respective period is calculated, which is subsequently used as each product line's weight in the regression model. Naturally, these weights sum to one. The weights for EBITDA for the three periods are shown in Tables 5, 6 and 7. The weights for total sales and total assets are presented in the Appendix.

Table 5
Product line share of EBITDA 1998-2002

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0%	32%	29%	0%	25%	15%	100%
Stora Enso Oyj	0%	67%	24%	0%	3%	6%	100%
Svenska Cellulosa AB	0%	16%	32%	45%	7%	0%	100%
Procter & Gamble Company	0%	0%	0%	27%	0%	73%	100%
Georgia Pacific	0%	17%	23%	38%	15%	7%	100%
Kimberly-Clark Corp.	0%	0%	0%	100%	0%	0%	100%
UPM-Kymmene Corp.	0%	89%	6%	0%	5%	0%	100%
Weyerhaeuser Company Limited	7%	13%	18%	0%	20%	42%	100%
Smurfit-Stone Container Corp.	0%	0%	100%	0%	0%	0%	100%
M-Real Corp.	8%	45%	18%	10%	0%	20%	100%
Paperlinx Limited	0%	52%	29%	0%	0%	19%	100%
Meadwestvaco Corp.	0%	22%	62%	0%	0%	16%	100%
Amcor Limited	0%	0%	40%	0%	0%	60%	100%
Sappi Limited	0%	70%	0%	0%	30%	0%	100%
Abitibi-Consolidated Inc	0%	89%	0%	0%	11%	0%	100%
Norske Skogindustrier	5%	94%	0%	0%	0%	0%	100%
Domtar Inc	0%	77%	16%	0%	5%	2%	100%
Rengo Company Limited	0%	0%	86%	0%	0%	14%	100%
Bowater Inc	0%	52%	0%	0%	28%	21%	100%
Cascades Inc	0%	12%	49%	21%	0%	18%	100%
Temple Inland Inc	0%	0%	41%	0%	25%	34%	100%
Empresas CMPC SA	44%	28%	9%	17%	0%	3%	100%
Tembec Inc	40%	32%	4%	0%	22%	3%	100%
Mayr-Melnhof Karton AG	0%	0%	100%	0%	0%	0%	100%
Holmen AB	0%	46%	26%	0%	4%	24%	100%
Rock Tenn	0%	0%	100%	0%	0%	0%	100%
Smith (DS) PLC	0%	0%	51%	0%	0%	49%	100%
Catalyst Paper Corp.	10%	41%	0%	0%	0%	49%	100%
Aracruz Celulose SA	100%	0%	0%	0%	0%	0%	100%
Portucel Empresa	33%	61%	0%	0%	1%	4%	100%
Nampak Limited	0%	0%	31%	0%	0%	69%	100%
Suzano Papel E Celulose SA	1%	68%	30%	0%	0%	0%	100%
Votorantim Celulose Papel SA	68%	32%	0%	0%	0%	0%	100%
Wausau Paper Corp.	0%	41%	0%	34%	0%	24%	100%
Potlatch Corp.	0%	6%	17%	16%	12%	49%	100%
West Fraser Timber	0%	0%	0%	0%	63%	37%	100%
Caraustar Industries	0%	0%	100%	0%	0%	0%	100%
Canfor	27%	0%	11%	0%	54%	8%	100%
Longview Fibre Company	0%	0%	43%	0%	57%	0%	100%
Cheng Loong Company Limited	0%	13%	73%	0%	0%	14%	100%
Mercer International Inc	54%	46%	0%	0%	0%	0%	100%
Gascogne	0%	0%	41%	0%	41%	18%	100%
Greif Inc	0%	0%	43%	0%	23%	35%	100%
Grupo Empresarial ENCE	85%	0%	0%	0%	6%	9%	100%
Otor	0%	0%	100%	0%	0%	0%	100%
Pope & Talbot Inc	43%	0%	0%	0%	57%	0%	100%
Rottneros	95%	0%	0%	0%	5%	0%	100%
Average	13%	25%	29%	7%	11%	16%	100%
							Total
Count of product-lines	15	26	31	9	23	30	134
Number of pure-player firms	1	0	5	1	0	0	7

Note: The table presents the product-line share of EBITDA for the period 1998-2002 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 6
Product line share of EBITDA 2003-2006

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0%	40%	29%	0%	25%	6%	100%
Stora Enso Oyj	0%	57%	33%	0%	5%	5%	100%
Svenska Cellulosa AB	0%	11%	28%	49%	12%	0%	100%
Procter & Gamble Company	0%	0%	0%	18%	0%	82%	100%
Georgia Pacific	0%	4%	17%	46%	29%	4%	100%
Kimberly-Clark Corp.	0%	0%	0%	100%	0%	0%	100%
UPM-Kymmene Corp.	0%	82%	9%	0%	9%	0%	100%
Weyerhaeuser Company Limited	2%	4%	17%	0%	26%	52%	100%
Smurfit-Stone Container Corp.	0%	0%	100%	0%	0%	0%	100%
M-Real Corp.	0%	55%	39%	0%	0%	6%	100%
Paperlinx Limited	0%	25%	12%	0%	0%	63%	100%
Meadwestvaco Corp.	0%	0%	55%	0%	0%	45%	100%
Amcor Limited	0%	0%	39%	0%	0%	61%	100%
Sappi Limited	0%	56%	0%	0%	44%	0%	100%
Abitibi-Consolidated Inc	0%	83%	0%	0%	17%	0%	100%
Norske Skogindustrier	0%	99%	0%	0%	0%	1%	100%
Domtar Inc	0%	77%	0%	0%	19%	4%	100%
Rengo Company Limited	0%	0%	87%	0%	0%	13%	100%
Bowater Inc	17%	63%	0%	0%	10%	9%	100%
Cascades Inc	0%	3%	56%	32%	0%	9%	100%
Temple Inland Inc	0%	0%	35%	0%	31%	34%	100%
Sonoco Products Company	0%	0%	78%	0%	0%	22%	100%
Graphic Packaging Corp.	0%	0%	100%	0%	0%	0%	100%
Empresas CMPC SA	48%	26%	6%	14%	0%	6%	100%
Packaging Corp. Of America	0%	0%	100%	0%	0%	0%	100%
Tembec Inc	41%	28%	0%	0%	24%	7%	100%
Mayr-Melnhof Karton AG	0%	0%	100%	0%	0%	0%	100%
Holmen AB	0%	41%	32%	0%	2%	25%	100%
Rock Tenn	0%	0%	100%	0%	0%	0%	100%
Smith (DS) PLC	0%	0%	68%	0%	0%	32%	100%
Catalyst Paper Corp.	5%	25%	0%	0%	0%	69%	100%
Aracruz Celulose SA	100%	0%	0%	0%	0%	0%	100%
Portucel Empresa	37%	61%	0%	0%	1%	1%	100%
Nampak Limited	0%	0%	30%	0%	0%	70%	100%
Suzano Papel E Celulose SA	25%	58%	17%	0%	0%	0%	100%
Votorantim Celulose Papel SA	60%	40%	0%	0%	0%	0%	100%
Klabin SA	0%	0%	88%	0%	0%	12%	100%
Wausau Paper Corp.	0%	16%	0%	51%	0%	33%	100%
Billerud AB	13%	0%	87%	0%	0%	0%	100%
Potlatch Corp.	0%	0%	21%	11%	25%	42%	100%
West Fraser Timber	0%	0%	0%	0%	86%	14%	100%
Caraustar Industries	0%	0%	100%	0%	0%	0%	100%
Canfor	29%	0%	0%	0%	71%	0%	100%
Longview Fibre Company	0%	0%	28%	0%	72%	0%	100%
Cheng Loong Company Limited	0%	12%	74%	0%	0%	14%	100%
Mercer International Inc	78%	22%	0%	0%	0%	0%	100%
Gascogne	0%	0%	55%	0%	23%	22%	100%
Greif Inc	0%	0%	27%	0%	0%	73%	100%
VPK Packaging	0%	0%	95%	0%	0%	5%	100%
Grupo Empresarial ENCE	86%	0%	0%	0%	14%	0%	100%
Otor	0%	0%	100%	0%	0%	0%	100%
Pope & Talbot Inc	47%	0%	0%	0%	53%	0%	100%
Rottneros	98%	0%	0%	0%	2%	0%	100%
Neenah Paper	23%	61%	0%	0%	0%	16%	100%
Average	13%	19%	34%	6%	11%	16%	100%
							Total
Count of product-lines	16	25	34	8	22	32	137
Number of pure-player firms	1	0	7	1	0	0	9

Note: The table presents the product-line share of EBITDA for the period 2003-2006 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 7
Product line share of EBITDA 1998-2006

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0%	36%	29%	0%	25%	10%	100%
Stora Enso Oyj	0%	62%	28%	0%	4%	5%	100%
Svenska Cellulosa AB	0%	13%	30%	47%	10%	0%	100%
Procter & Gamble Company	0%	0%	0%	23%	0%	77%	100%
Georgia Pacific	0%	10%	20%	42%	22%	6%	100%
Kimberly-Clark Corp.	0%	0%	0%	100%	0%	0%	100%
UPM-Kymmene Corp.	0%	85%	7%	0%	7%	0%	100%
Weyerhaeuser Company Limited	5%	8%	17%	0%	23%	47%	100%
Smurfit-Stone Container Corp.	0%	0%	100%	0%	0%	0%	100%
M-Real Corp.	4%	50%	28%	5%	0%	13%	100%
Paperlinx Limited	0%	38%	21%	0%	0%	41%	100%
Meadwestvaco Corp.	0%	11%	58%	0%	0%	31%	100%
Amcor Limited	0%	0%	40%	0%	0%	60%	100%
Sappi Limited	0%	63%	0%	0%	37%	0%	100%
Abitibi-Consolidated Inc	0%	86%	0%	0%	14%	0%	100%
Norske Skogindustrier	3%	97%	0%	0%	0%	1%	100%
Domtar Inc	0%	77%	8%	0%	12%	3%	100%
Rengo Company Limited	0%	0%	87%	0%	0%	13%	100%
Bowater Inc	9%	58%	0%	0%	19%	15%	100%
Cascades Inc	0%	8%	52%	26%	0%	13%	100%
Temple Inland Inc	0%	0%	38%	0%	28%	34%	100%
Empresas CMPC SA	46%	27%	7%	16%	0%	4%	100%
Tembec Inc	40%	30%	2%	0%	23%	5%	100%
Mayr-Melnhof Karton AG	0%	0%	100%	0%	0%	0%	100%
Holmen AB	0%	44%	29%	0%	3%	25%	100%
Rock Tenn	0%	0%	100%	0%	0%	0%	100%
Smith (DS) PLC	0%	0%	60%	0%	0%	40%	100%
Catalyst Paper Corp.	8%	33%	0%	0%	0%	59%	100%
Aracruz Celulose SA	100%	0%	0%	0%	0%	0%	100%
Portucel Empresa	35%	61%	0%	0%	1%	2%	100%
Nampak Limited	0%	0%	30%	0%	0%	70%	100%
Suzano Papel E Celulose SA	13%	63%	24%	0%	0%	0%	100%
Votorantim Celulose Papel SA	64%	36%	0%	0%	0%	0%	100%
Wausau Paper Corp.	0%	29%	0%	43%	0%	29%	100%
Potlatch Corp.	0%	3%	19%	14%	19%	46%	100%
West Fraser Timber	0%	0%	0%	0%	74%	26%	100%
Caraustar Industries	0%	0%	100%	0%	0%	0%	100%
Canfor	28%	0%	6%	0%	63%	4%	100%
Longview Fibre Company	0%	0%	35%	0%	65%	0%	100%
Cheng Loong Company Limited	0%	12%	73%	0%	0%	14%	100%
Mercer International Inc	66%	34%	0%	0%	0%	0%	100%
Gascogne	0%	0%	48%	0%	32%	20%	100%
Greif Inc	0%	0%	35%	0%	11%	54%	100%
Grupo Empresarial ENCE	86%	0%	0%	0%	10%	4%	100%
Otor	0%	0%	100%	0%	0%	0%	100%
Pope & Talbot Inc	45%	0%	0%	0%	55%	0%	100%
Rottneros	96%	0%	0%	0%	4%	0%	100%
Average	14%	23%	28%	7%	12%	16%	100%

							Total
Count of product-lines	16	26	31	9	23	30	135
Number of pure-player firms	1	0	5	1	0	0	7

Note: The table presents the product-line share of EBITDA for the period 1998-2006 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

6.3. Limitations of the study

The main limitation of the study is its sample size: a standard 'rule of thumb' for multiple regression analysis in econometrics textbooks (e.g. Tabachnick and Fidell, 2001) is to have more than roughly 20 cases per independent variable, my sample having only 9 or 10,8 depending on whether the 'Other'-category is accounted for or not. However, the same sources recommend a minimum of around five cases per independent for serious research, which is fortunately clearly exceeded. Natale (2005) in his application of the full-information approach for a study of European insurance firms, estimates betas with a total of ten independents using a sample of only 64 companies. Not surprisingly, only a few of his estimated subindustry betas turn out to be significant. The drawback of a small sample is naturally that the estimates produced are not as reliable as with a larger sample.

Chua, Chang and Wu (2006) identify two potential sources of bias in the application of the full-information approach, a missing variable problem and a missing data problem. The missing variable problem concerns a situation where there is no variable defined for an unreported line of business. The missing data problem, on the other hand, originates when an unreported line of business does have a variable in the model. These problems can arise because firms do not have to report results for minor lines of business. This means that the weights in the regression model do not necessarily add to one. This problem is especially evident with the data used in their study, where the combined division sales do not necessarily equal the total sales of a firm, but can remain below this. The segment reports of the firms in this study do not exhibit this problem. Of course, this does not mean that these problems are not present with the data used here because unreported lines can still exist. However, the problems are likely to be minor as there is not much reason to believe that the sample firms would have numerous unreported lines per firm.

This study defines an additional 'Other' category to classify the operations that do not fit the classification scheme, which should control for potential bias caused by non pulp and paper businesses the firms operate in.

7. Model estimation

Following the methodology of Chua, Chang and Wu (2006) and based on the product line classification from Section 5.2 the following cross-sectional regression model is now estimated:

$$\begin{aligned}\beta_{mi} &= \beta_{fiPulp}\omega_{iPulp} + \beta_{fiWhite}\omega_{iWhite} + \beta_{fiPackaging}\omega_{iPackaging} + \beta_{fiTissue}\omega_{iTissue} \\ &+ \beta_{fiWoodproducts}\omega_{iWoodproducts} + \beta_{fiOther}\omega_{iOther} + \nu_i,\end{aligned} \tag{9}$$

where β_{mi} is the observed market beta for firm i, β_{fi} is the full-information product-line beta for the respective product line as denoted by the subscript Pulp, White, etc. of firm i, ω_i is firm i's participation weight for the respective product line, again denoted by its name in the subscript and ν_i is the random error term for firm i. The regression is run by substituting for β_{mi} either the normal i.e. levered market beta or one of the two unlevered betas calculated as described under Section 3.3. The participation weights used are either based on EBITDA, sales or assets and they are calculated as described in Section 6.2. This results in nine different models being estimated for each of the three periods. Thus, a total of twenty-seven models are estimated.

I also consider estimating a market-capitalization-weighted WLS model; however, as the sample shows no statistically significant correlation of market beta and market capitalization (see Table 16 in the Appendix), I only estimate the OLS variant.

7.1. Multicollinearity

A potential problem with this type of model is the issue of multicollinearity, i.e. the case where two or more of the independent variables, here the participation weights, are highly correlated with each other. If multicollinearity exists, the estimates for the regression coefficients become unreliable as the standard errors are increased. The reason to expect multicollinearity is that there exists a theoretically perfectly linear relationship between the independent variables since they are weights that sum up to one. However, with the data at hand, most likely due to having enough independents, the effect is not severe enough to cause problems. The simplest way to check for multicollinearity is to compute a correlation matrix of the independent variables. This is done in Table 8 for the EBITDA weights for the period 2003-2006.

Table 8
EBITDA weights correlation matrix 2003-2006

	Pulp	White	Packaging	Tissue	Wood prod.	Other
Pulp	1.00	-0.02	-0.43	-0.14	-0.03	-0.30
White	-0.02	1.00	**-0.46**	-0.16	-0.08	-0.23
Packaging	-0.43	**-0.46**	1.00	-0.19	-0.33	-0.13
Tissue	-0.14	-0.16	-0.19	1.00	-0.07	-0.04
Wood prod.	-0.03	-0.08	-0.33	-0.07	1.00	-0.15
Other	-0.30	-0.23	-0.13	-0.04	-0.15	1.00

Notes: The highest correlation is bolded

A common rule (Lewis-Beck, 1993) is that multicollinearity is a problem if more than one of the cross-correlations of the independents are higher than 0.7. As the highest absolute correlation (0.46) is clearly below this threshold, I conclude that multicollinearity is not an issue with this dataset. The same also applies for the two other study periods as well as the sales and assets-based weights. The regression results also confirm this, as the standard errors of the regression coefficients are low enough to provide significant estimates for all the models.

7.2. Control variables

The following two variables that could potentially affect the results are identified: the size of the firms as measured by their market capitalization and the operating location and/or stock exchange location of the firms. The former shows a high variability in the samples as is seen from the summary statistics in Tables 2-4. Because the correlation between market capitalization and beta turned out to be insignificant for the samples, it is expected that the inclusion of market capitalization as a further independent variable has no significant effect on the model. This is confirmed by the results shown in Table 9: when market capitalization is added as an independent to the 1998-2006 model with EBITDA weighting, the null hypothesis that its coefficient is zero cannot be rejected even at the 10 % -level.

Table 9
Test of market cap. control variable

	Estimate	Sig.
Wood prod.	1.283869	0.00
White	1.238901	0.00
Pulp	1.018683	0.00
Packaging	0.914906	0.00
Tissue	0.839827	0.01
Marketcap	-0.000004	0.18

Note: Sig. denotes significance level. Marketcap denotes market capitalization.

The effect of location is tested by defining a 'North America' (NA) dummy variable based on the main operating area of the company. It takes the value of one for companies with their main operating area in North America (the United States and Canada) and zero for those outside and is included as an independent in the model. Again, the 1998-2006 model with EBITDA weighting is estimated including this new variable. Table 10 presents the result: here as well the null hypothesis that the NA- coefficient is zero can not be rejected even at the 10 % -level.

Table 10
Test of area control variable

	Estimate	Sig.
White	1.224	0.00
Wood prod.	1.073	0.00
Pulp	1.014	0.00
Packaging	0.883	0.00
Tissue	0.541	0.08
NA dummy	0.160	0.22

Note: Sig. denotes significance level. NA dummy is the North America area dummy variable.

I thus conclude that both tested variables have no significant effect on the models and that they are not needed as control variables. I proceed by estimating the cross-sectional regression models as originally defined in Equation (9). The next section presents the results.

7.3. Regression results with weighting by EBITDA, assets and sales

The regression results for weighting with EBITDA are presented in Table 11, with assets in Table 12 and with sales in Table 13. In each table, the five product lines are arranged by their size of estimated beta.

Table 11
Full information approach product-line betas
Value proxy: EBITDA

		1998 - 2002			2003 - 2006			1998 - 2006			
Levered											Average R^2
Raw beta	White	1.33	(***)	White	1.50	(***)	Wood prod.	1.30	(***)		
	Wood prod.	1.28	(***)	Wood prod.	1.38	(***)	White	1.23	(***)		
	Pulp	1.19	(***)	Tissue	0.93	(**)	Pulp	1.02	(***)		
	Packaging	0.86	(***)	Packaging	0.91	(***)	Packaging	0.94	(***)		
	Tissue	0.66	(**)	Pulp	0.88	(***)	Tissue	0.70	(**)		
	R^2	0.88		R^2	0.79		R^2	**0.90**			0.86
	n	47		n	54		n	47			
Unlevered											
M&M no tax	Pulp	0.74	(***)	White	0.81	(***)	Wood prod.	0.62	(***)		
	White	0.68	(***)	Tissue	0.54	(**)	Pulp	0.61	(***)		
	Wood prod.	0.55	(***)	Wood prod.	0.53	(***)	White	0.61	(***)		
	Tissue	0.42	(**)	Pulp	0.46	(***)	Tissue	0.49	(***)		
	Packaging	0.36	(***)	Packaging	0.43	(***)	Packaging	0.43	(***)		
	R^2	0.87		R^2	0.82		R^2	0.87			0.85
	n	47		n	54		n	47			
Hamada-type (with taxes)	White	0.82	(***)	White	0.91	(***)	Wood prod.	0.77	(***)		
	Pulp	0.79	(***)	Wood prod.	0.66	(***)	White	0.71	(***)		
	Wood prod.	0.76	(***)	Tissue	0.62	(**)	Pulp	0.65	(***)		
	Packaging	0.48	(***)	Packaging	0.55	(***)	Packaging	0.54	(***)		
	Tissue	0.45	(**)	Pulp	0.53	(***)	Tissue	0.52	(***)		
	R^2	0.87		R^2	0.82		R^2	0.88			0.85
	n	46		n	48		n	47			
Average R^2		0.87			0.81			0.88			

Notes: The table reports the results for the cross-sectional regression model specificed in equation (9). Coefficients significant at the 1%-level are denoted by (***), at the 5%-level by (**) and at the 10%-level by (*). The top row reports the results calculated with the raw market beta (sum-beta adjusted) as defined in equation (4), the second row with the beta unlevered according to the Miller-Modigliani assumptions as defined in equation (5) and the last row with the beta unlevered according to Hamada as defined in equation (6). R_2 denotes the R-square of the model and n the number of observations (firms).

Table 12
Full information approach product-line betas
Value proxy: Assets

		1998 - 2002			2003 - 2006			1998 - 2006			
Levered											Average R^2
Raw beta	Wood prod.	1.57	(***)	White	1.54	(***)	Wood prod.	1.39	(***)		
	White	1.32	(***)	Pulp	1.07	(***)	White	1.22	(***)		
	Pulp	1.15	(***)	Tissue	1.02	(**)	Pulp	1.04	(***)		
	Tissue	0.92	(***)	Wood prod.	0.93	(*)	Tissue	0.92	(***)		
	Packaging	0.83	(***)	Packaging	0.91	(***)	Packaging	0.92	(***)		
	R^2	0.89		R^2	0.79		R^2	**0.90**			0.86
	n	47		n	54		n	47			
Unlevered											
M&M no tax	Wood prod.	0.71	(***)	White	0.84	(***)	Wood prod.	0.73	(***)		
	Pulp	0.69	(***)	Tissue	0.53	(**)	White	0.62	(***)		
	White	0.68	(***)	Pulp	0.49	(***)	Pulp	0.57	(***)		
	Tissue	0.47	(**)	Wood prod.	0.47	(*)	Tissue	0.53	(***)		
	Packaging	0.37	(***)	Packaging	0.44	(***)	Packaging	0.44	(***)		
	R^2	0.87		R^2	0.82		R^2	0.87			0.85
	n	47		n	54		n	47			
Hamada-type (with taxes)	Wood produ	1.00	(***)	White	0.95	(***)	Wood prod.	0.92	(***)		
	White	0.82	(***)	Tissue	0.61	(**)	White	0.72	(***)		
	Pulp	0.74	(***)	Wood prod.	0.57	(**)	Pulp	0.60	(***)		
	Tissue	0.55	(***)	Packaging	0.57	(***)	Tissue	0.60	(***)		
	Packaging	0.49	(***)	Pulp	0.56	(***)	Packaging	0.55	(***)		
	R^2	0.88		R^2	0.82		R^2	0.88			0.86
	n	46		n	48		n	47			
Average R^2		0.88			0.81			0.88			

Notes: The table reports the results for the cross-sectional regression model specificed in equation (9). Coefficients significant at the 1%-level are denoted by (***), at the 5%-level by (**) and at the 10%-level by (*). The top row reports the results calculated with the raw market beta (sum-beta adjusted) as defined in equation (4), the second row with the beta unlevered according to the Miller-Modigliani assumptions as defined in equation (5) and the last row with the beta unlevered according to Hamada as defined in equation (6). R_2 denotes the R-square of the model and n the number of observations (firms).

Table 13
Full information approach product-line betas
Value proxy: Sales

		1998 - 2002			2003 - 2006			1998 - 2006			
Levered											Average R^2
Raw beta	Wood prod.	1.58	(***)	White	1.56	(***)	Wood prod.	1.51	(***)		
	White	1.33	(***)	Wood prod.	1.39	(***)	White	1.26	(***)		
	Pulp	1.10	(***)	Packaging	0.98	(***)	Pulp	0.98	(***)		
	Packaging	0.81	(***)	Pulp	0.95	(***)	Packaging	0.93	(***)		
	Tissue	0.49		Tissue	0.83		Tissue	0.59	(**)		
	R^2	0.89		R^2	0.79		R^2	**0.90**			0.86
	n	47		n	54		n	47			
Unlevered											
M&M no tax	Pulp	0.73	(***)	White	0.84	(***)	Wood prod.	0.70	(***)		
	Wood prod.	0.68	(***)	Wood prod.	0.55	(**)	White	0.61	(***)		
	White	0.66	(***)	Tissue	0.50	(**)	Pulp	0.60	(***)		
	Tissue	0.40	(*)	Pulp	0.49	(***)	Tissue	0.47	(**)		
	Packaging	0.35	(***)	Packaging	0.45	(***)	Packaging	0.44	(***)		
	R^2	0.87		R^2	0.81		R^2	0.87			0.85
	n	47		n	54		n	47			
Hamada-type (with taxes)	Wood produ	0.93	(***)	White	0.94	(***)	Wood produ	0.89	(***)		
	White	0.79	(***)	Wood prod.	0.70	(***)	White	0.71	(***)		
	Pulp	0.76	(***)	Packaging	0.59	(***)	Pulp	0.63	(***)		
	Packaging	0.46	(***)	Tissue	0.56	(**)	Packaging	0.55	(***)		
	Tissue	0.41	(*)	Pulp	0.54	(***)	Tissue	0.49	(**)		
	R^2	0.88		R^2	0.81		R^2	0.88			0.86
	n	46		n	48		n	47			
Average R^2		0.88			0.80			0.88			

Notes: The table reports the results for the cross-sectional regression model specificed in equation (9). Coefficients significant at the 1%-level are denoted by (***), at the 5%-level by (**) and at the 10%-level by (*). The top row reports the results calculated with the raw market beta (sum-beta adjusted) as defined in equation (4), the second row with the beta unlevered according to the Miller-Modigliani assumptions as defined in equation (5) and the last row with the beta unlevered according to Hamada as defined in equation (6). R_2 denotes the R-square of the model and n the number of observations (firms).

7.4. Interpretation of the results

A first glance at the results reveals a surprisingly high R^2, above 79 %, for all of the estimated models. The null hypothesis of the F-test for the goodness of fit that the model has no explanatory power at all is rejected in all models at the 0.1 %-level and is thus not included in the tables. The coefficient for the 'Other'-category has no meaningful interpretation and is thus not reported.

The R^2 s are much higher than the R^2 s of around 0.25 reported by Chua, Chang and Wu (2006), the only study using the FI approach that reports an R^2 albeit without stating the number of independents and sample size. However, the mentioned study as well as most other studies use a large sample and assign firms to industries based on their sales by Standard Industry Classification (SIC) code. The data used in these studies seem to have certain problems, e.g. the authors report that it is common for their sales data by SIC code not to add up to total sales for a firm. The SIC code based classification method is arguably a much less precise method than the segment reporting based subindustry classification used in this study. Thus, the results are not directly comparable to those of previous studies.

The R^2s are almost identical between the three value proxies used, but the estimates produced with sales-based weighting carry less significant or even insignificant coefficients as compared to their EBITDA and asset based equivalents. This is as expected, since EBITDA as a quasi substitute for cash-flow and assets as a measure of production facility value should be superior to sales in measuring division value.

There is also a clear difference in R^2 between the three sample periods: the 2003-2006 period has a clearly lower R^2 than the earlier subperiod 1998-2002 and the whole period 1998-2006. This is quite likely due to the differing samples, as the 1998-2002 and the 1998-2006 samples contain the same firms, while the 2003-2006 period contains seven firms more.

The next question concerns the type of beta and method of unlevering. It is commonplace to assume that the decisions about capital structure are made at the firm-level by top management as opposed to at the divisional level. By this reasoning, to make the betas comparable, they should first be unlevered to remove the effect the capital structure decision has on the riskiness of the equity. These asset betas then describe the riskiness of the assets of the whole firm. The described procedure is the way the unlevering is performed in this study and the results are presented on the second and third rows of the tables. The models estimated with the Hamada-type beta should be treated with caution due to the questionable quality of effective tax rate data as discussed in Section 6.2. Interestingly though, the models, in terms of R^2, perform as well as the models where the betas are unlevered with the M&M assumptions without considering taxes.

When estimating the model with the levered market betas, differences in capital structure are not controlled for, i.e. it is implicitly assumed that there is an optimal D/E ratio for each product line and firm, and that all firms are at the optimum. The results for this type of model are presented in the first row of the tables.

It is interesting to note that the R^2s are slightly higher for the models with levered betas than the ones with unlevered betas for the periods 1998-2002 and 1998-2006. What this potentially implies is that either the models for unlevering are not realistic enough, or alternatively, that the seemingly unrealistic assumption about an equal optimum D/E that all firms are at is in fact true. However, due to the small sample size and the differing results between the three samples, it is not possible to draw any definitive conclusions here.

The estimated coefficients are interpreted as follows: for the levered beta model the coefficients stand for a levered beta of the respective product line. In this case it is assumed that leverage affects the sample firms and divisions evenly, which does not seem very realistic as is evidenced by the highly variable capital structure of the sample firms. For the unlevered beta models, the coefficients are interpreted as asset betas of the respective product line. When comparing the results of the levered and unlevered models, it can be noted that not only the size of the estimated betas changes, but also the relative order of the product lines. This is a result of the differing capital structures and tax rates of the firms being taken into account.

A general look at the estimated coefficients for the studied product lines reveals the following: although there is variability in the order of the product lines between the models, there are also clear uniformities: the packaging and tissue product lines have lower ranking betas in most models, while wood products or white papers appear at the top in most cases. To some extent, the results confirm common intuition on the market sensitivity of these segments: the demand for wood products is heavily influenced by the housing market which is known to be a cyclical market. The demand for white papers, consisting of publication papers and fine papers which include e.g. magazine paper is partly influenced by the rather cyclical advertising sector. Of the end products of the pulp and paper industry, demand for tissue papers is arguably the least sensitive to market movements and general economic conditions as demand for consumer tissue should not be affected by these. However, with the existence of the away-from-home (AFH) tissue market which accounts for around a third (PPI Magazine, February 2007) of the whole tissue market and sells its products to hotels and restaurants etc., which are businesses of a more cyclical nature, the effect is probably made less pronounced. The differing results between the models raise the question which model should be preferred for a 'best estimate', a question that is not easily answered. This depends at least on the time horizon and business cycle considerations, which should be important when comparing (sub)industries with each other.

The range of estimated asset betas for the subindustries compares favorably to earlier studies (Damodaran, 2005 and Pöyry Capital, 2000) that report a Hamada-type asset beta of around 0.7 for the pulp and paper industry as a whole. No prior estimates of market betas for the studied subindustries were found to compare to the results obtained here.

7.5. Product-line average debt-to-equity ratios

The dataset also allows us to calculate average debt-to-equity ratios for the studied product-lines. The reason for doing this is the common expectation that certain optimal D/E –ratios exist for each sector due to the differing capability of businesses to carry debt. The calculation is performed in the same manner as the product-line betas are determined, only instead of the firm betas the debt-to-equity ratios of each firm are used as the dependent variables in the cross-sectional regression model. The independent variables are the same proxies for divisional value, each division's share of EBITDA and assets of the firm total. The results of the estimated models are presented in Table 14.

Table 14
Product-line average debt-to-equity ratios

Value proxy	1998 - 2002			2003 - 2006			1998 - 2006			Average R^2
EBITDA	Packaging	156%	(***)	Pulp	166%	(***)	Packaging	140%	(***)	
	Wood prod.	119%	(**)	White	118%	(**)	Wood prod.	120%	(**)	
	White	111%	(***)	Wood prod.	108%		White	120%	(***)	
	Pulp	79%	(**)	Packaging	100%	(***)	Pulp	118%	(***)	
	Tissue	45%		Tissue	10%		Tissue	34%		
	R^2	0.75		R^2	0.46		R^2	0.66		0.62
	n	47		n	54		n	47		
ASSETS	Packaging	143%	(***)	Pulp	194%	(***)	Pulp	176%	(***)	
	White	109%	(***)	White	111%	(**)	Packaging	127%	(***)	
	Wood prod.	93%		Packaging	94%	(***)	White	96%	(***)	
	Pulp	92%	(***)	Wood prod.	79%		Wood prod.	65%		
	Tissue	64%		Tissue	11%		Tissue	29%		
	R^2	0.72		R^2	0.47		R^2	0.67		0.62
	n	47		n	54		n	47		
Average R^2		0.73			0.47			0.66		

Notes: The table reports the results for the cross-sectional regression model discussed in Section 7.5. Coefficients significant at the 1%-level are denoted by (***), at the 5%-level by (**) and at the 10%-level by (*). R_2 denotes the R-square of the model and n the number of observations (firms).

The models have considerably lower explanatory power than the above models with betas. None of the three samples is able to produce significant estimates for all product-lines (the estimate for tissue papers is insignificant in each model) and the estimates vary widely between the samples. This suggests that leverage is not determined as clearly by in which subindustries the firm is active as is systematic risk. It lends some support to the view that leverage is determined at the firm level as opposed to at the divisional level and that divisional leverage is not uniform across divisions that operate in the same subindustry for all of the studied product-lines.

Although the main objective of this study is the determination of asset betas which are presented in Section 7.3., it is possible to use the subindustry average D/E – ratio estimates to calculate the average levered cost of equity for the subindustries, mainly for an illustrative purpose. For this, estimates for the risk-free rate and market premium are also needed. The risk-free rate used in the calculation is 4.0 % and the equity market premium 5.2 %. The levered cost of equity estimates are based on the 1998 – 2006 figures and the re-levering is performed with the M&M –formula that does not consider taxes. This is done as there is no reason to expect a uniform tax rate in each subindustry (tax rates depend on the operating countries of the firms). The results are presented in Table 15.

Table 15
Levered cost of equity based on average subindustry D/E -ratios
Illustrative calculation with risk-free rate of 4 % and equity premium of 5.2 %

	D/E	Asset beta	Unlevered cost of equity	Levered beta	Levered cost of equity
Wood products	120%	0.62	7.22%	1.37	11.10%
White papers	120%	0.61	7.17%	1.34	10.97%
Pulp	118%	0.61	7.17%	1.33	10.91%
Packaging	140%	0.43	6.24%	1.03	9.36%

Notes: This table illustrates how the determined asset betas and industry average D/E -ratios can be used to calculate estimates of the average leveraged cost of equity for each subindustry. The figures are based on the estimates for the 1998 - 2006 sample. The category 'Tissue' is not included as no significant sector D/E -ratio could be determined. The risk-free rate used is 4.0 % and the equity premium 5.2 %. The calculation relies on the M&M (no tax) formula for leverage.

8. Conclusion

This study provides evidence that it is possible to employ the full-information (FI) approach on a detailed, subindustry level with the help of segment reporting data. It is, to my best knowledge, the first study that uses segment reporting data to classify divisions into subindustries, here termed product lines, to estimate betas for them using the FI approach. All the estimated models prove to be statistically significant. Estimating betas for product lines is important as it is a well known fact that using an incorrect beta and hence incorrect cost of capital will lead to inefficient allocation of capital. A typical situation where this problem arises is when a single beta is used for divisions with crucially differing operations.

The resulting estimates of beta produced by this study, however, have to be interpreted with caution due to the following reasons: first, the sample size, although providing statistically significant results, is not as large as recommended by econometrics textbooks for multiple regression analysis. Second, the high amount of vertical integration in the pulp and paper industry quite probably introduces some bias into the results. For example, many firms produce most or all of the pulp they need, while others buy it in the market. The risk profiles of more or less integrated firms are however likely to be different. A correction for this could be attempted by adding a parameter to the model that measures how much pulp is bought from the market, however this data is not readily available for all firms and remains a possibility for further study. Third, a common concern when estimating beta applies here as well: during the sample period numerous M&A transactions have taken place in the industry and have undoubtedly changed the risk profiles of the firms to some extent. This can be a potential source of bias if these effects are not distributed evenly among the studied product lines. Last, as this is a capital market study, a few important non-listed players in the pulp and paper industry such as Mondi and Burgo could naturally not be included in the analysis.

The mentioned issues concerning the estimates notwithstanding, the study shows that the full-information approach is successfully applicable even for a small sample size with segment reporting data used as value proxy. Previous studies by Kaplan and Peterson (1998) and Chua, Chang and Wu (2006) have concentrated on estimating industry betas using large data sets containing companies from all sectors of the economy and distinguish industries based on companies' Standard Industry Classification (SIC) codes. The SIC system is the oldest of the classification schemes and is being replaced by newer systems such as the NAICS and GICS, that according to a study by Bhojraj, Lee and Oler (2003) are better suited for capital market research than the SIC system. Two further studies by Cummins and Phillips (2005) and Natale (2005) estimate subindustry betas for the insurance industry, but also accomplish this by using sales data only. The four mentioned studies that use the FI approach are the only ones that were found when doing background research for this study. The reason why the method has not been widely used or studied since its invention in 1991 is most likely due to its rather laborious nature, especially if the segment classifications and assignments are done manually such as in this study.

I conclude that the thesis contributes to the existing cost of capital literature by showing that it is possible to successfully employ the full-information approach while also likely increasing its accuracy by using detailed segment reporting data. Evidence for this is provided by the fact that EBITDA and assets are shown to be better proxies for division value than sales. Also, the generally high fit of all the estimated models points toward this conclusion.

Interesting possibilities for further research include adding additional risk factors to the model, incorporating a form of time-varying beta in the model, including factors that measure and correct for the extent of how integrated a business is and coming up with more advanced methods of unlevering betas.

References

Amihud, Y., Christensen, B.J. and Mendelson, H., 1993, "Further evidence on the risk-return relationship", Working Paper, New York University

Ané, T. and Geman, H., 2000, "Order flow, transaction clock and normality of asset returns", *Journal of Finance* 55, 2259-2284

Ang, A. and Chen, J., 2005, "CAPM over the long run: 1926 – 2001", 2007, *Journal of Empirical Finance* 14(1), 1-40

Ball, R. and Brown, P., 1969, "Portfolio Theory and Accounting Theory", *Journal of Accounting Research,* 7, 300-323

Banz, R., 1981, "The Relationship between Return and Market Value of Common Stock", *Journal of Financial Economics* 9, 3-18

Bhojraj, S., Lee, C. and Oler, D., 2003, "What's My Line? A Comparison of Industry Classification Schemes for Capital Market Research", *Journal of Accounting Research* 41(5), 745-774

Black, F., Jensen, M. and Scholes, M., 1972, "The capital asset pricing model: some empirical tests", *Studies in the Theory of Capital Markets,* Praeger, New York, 79-124

Black, F., 1993, "Beta and Return", *Journal of Portfolio Management* 20, 8-18

Bodie, Z., Kane, A. and Marcus, A., 2002, *Investments*, 5th Edition, Prentice Hall

Bollerslev, T., Engle, R.F. and Woolridge, J.M., 1988, "A capital asset pricing model with time varying covariances", *Journal of Political Economy* 96, 116-131

Booth, 1999, "Estimating the Equity Risk and Equity Cost: New Ways of Looking at Old Data", *Journal of Applied Corporate Finance* 12(1), 100-112

Bos, T. and Newbold, P., 1984, "An empirical investigation of the possibility of stochastic systematic risk in the market model", *Journal of Business* 57, 35-41

Bowman, R. and Bush, S., 2006, "Using Comparable Companies to Estimate the Betas of Private Companies", *Journal of Applied Finance* Fall/Winter

Brealey, R. and Myers, S., 2003, *Principles of Corporate Finance*, 7th Edition, McGraw-Hill

Brounen, D., de Jong, A. and Koedijk, K., 2004, "Corporate Finance in Europe: Confronting Theory with Practice", *Financial Management* Winter 2004, 71-101

Bruner, R. F., K. Eades, R. Harris and R. Higgins, 1998, "Best Practices in Estimating the Cost of Capital: Survey and Synthesis," *Financial Practice and Education* 8(1), 13-28

Chan, K.C. and Chen, N., 1988, "An Unconditional Asset-Pricing Test and the Role of Firm Size as an Instrumental Variable for Risk," *Journal of Finance* June, 309-325

Chen, S.N., 1982, "An examination of risk-return relationship in bull and bear markets using time-varying security betas", *Journal of Financial and Quantitative Analysis* 17, 265-286

Chua, J., Chang P.C. and Wu, Z., 2006, "The Full-Information Approach for Estimating Divisional Betas: Implementation Issues and Tests", *Journal of Applied Finance* Spring/Summer, 53-61

Christie-David, R. and Chaudhry, M., 2001, "Coskewness and cokurtosis in futures markets", *Journal of Empirical Finance* 8, 55-81

Chung, Y.P., Johnson, H. and Schill, M.J., 2006, "Asset Pricing When Returns Are Nonnormal: Fama-French Factors vs. Higher-order Systematic Co-Moments", *The Journal of Business* 79(2)

Coleman, R. D., 2006, "Asset Pricing Simultaneities: Phases and Patterns", *Annals of Economics and Finance* 1, 49-76

Corhay, A., 1992, "The intervalling effect bias in beta: A note", *Journal of banking and Finance* 16, 61-73

Crombez, J. and Vander Vennet, R., 2000, "Risk/return relationship conditional on market movements on the Brussels stock exchange", *Tijdschrift voor Economie en Management* 45, 163-188

Cummins, J. D. and R. D. Phillips, 2005, "Estimating the Cost of Equity Capital for Property-Liability Insurers", *The Journal of Risk and Insurance* 72(3), 441-478

Damodaran, A., 2000, "Estimating risk parameters", Working Paper, Stern School of Business, New York

Damodaran, A., 2005, Data Set: Total Beta by Industry Sector, http://pages.stern.nyu.edu/~adamodar/, Stern School of Business, New York

Davis, J., 1994, "The cross-section of realized stock returns: the pre-COMPUSTAT evidence", *Journal of Finance* 49, 1579-1593

Douglas, G.W., 1969, "Risk in the equity markets: an empirical appraisal of market efficiency", *Yale Economic Essays* 9, 3-45

Ehrhardt, M. and Y. Bhagwat, 1991, "A Full-Information Approach for Estimating Divisional Betas," *Financial Management* 20(2), 60-69

Engle, R.F., 1982, "Autoregressive conditional heteroscedasticity with estimates of the variance of U.K. inflation", *Econometrica* 50, 122-150

Fabozzi, F.J. and Francis, J.C., 1978, "Beta as a random coefficient", *Journal of Financial and Quantitative Analysis* 13, 101-116

Faff, R. and Brooks, R.D., 1998, "Time-varying beta risk for Australian industry portfolios: an exploratory analysis", *Journal of Business Finance and Accounting* 25, 721-745

Faff, R., Lee, J. and Fry, T., 1992, “Time stationarity of systematic risk: some Australian evidence”, *Journal of Business Finance and Accounting* 19, 253-270

Fama, E. and French, K., 1992, "The Cross-section of expected returns", *Journal of Finance* 47, 427-465

Fama, E. and French, K., 1993, "Common Risk Factors in the Returns on Stocks and Bonds", *Journal of Financial Economics* 33, 3-56

Fama, E. and French, K., 1996, "Multifactor Explanations of Asset Pricing Anomalies", *Journal of Finance* 51, 55-84

Fama, E. and French, K., 2004, “The Capital Asset Pricing Model: Theory and Evidence”, *The Journal of Economic Perspectives* 18(3), 25-46

Fama, E. and MacBeth, J.D., 1973, “Risk, return and equilibrium: empirical tests”, *The Journal of Political Economy* 81, 607-636

Fang, H. and Lai, T-Y., 1997, “Cokurtosis and capital asset pricing“, *The Financial Review* 32, 293-307

Ferson, W.E. and Harvey, C.R., 1991, “The variation of economic risk premiums”, *Journal of Political Economy* 99, 385-415

Fraser, P., Hamelink, F., Hoesli, M. and MacGregor, B., 2000, “Time-varying betas and cross-sectional return-risk relation: evidence form the UK”, *Ecole des Hautes Etudes Commerciales*, University of Geneva, Switzerland

Friend, I. and Westerfield, R., 1980, “Co-skewness and capital asset pricing”, *Journal of Finance* 35, 897, 913

Fuller, R. and H. Kerr, 1981, “Estimating the Divisional Cost of Capital: An Analysis of the Pure-Play Technique”, *Journal of Finance* 36(5), 997-1009

Galagedera, D.U.A. and Silvapulle, P., 2002, "Conditional relation between higher-order co-moments and stock return: evidence from Australian data", *Proceedings of the Econometric Society Australasian Meeting*, Queensland University of Technology, Brisbane, Australia

Gonedes, N., 1973, "Evidence on the information content of accounting numbers: accounting-based and marketbased estimates of systematic risk", *Journal of Financial and Quantitative Analysis* 18, 407-443

Grinblatt, M. and Titman, S., 2002, *Financial Markets and Corporate Strategy,* 2nd edition, McGraw-Hill

Hamada, R.S., 1972, "The effect of the firm's capital structure on the systematic risk of common stocks", *Journal of Finance*, 435-452

Harvey, C. and Siddique, A., 2000, "Conditional skewness in asset pricing tests", *Journal of Finance* 55, 1263-1295

He, J. and Ng, L.K., 1994, "Economic forces, fundamental variables and equity returns, *Journal of Business* 67, 599-639

Horowitz, J.L, Loughran, T. and Savin, N.E., 2000, "The disappearing size effect", *Research in Economics* 54(1), 83-100

Ibbotson Associates, 2002, *Stocks, Bonds, Bills and Inflation – Valuation Edition, Yearbook*, Ibbotson Associates

Ibbotson, R.G., Kaplan, P.D and Peterson, J.D., 1997, "Estimates of small-stock betas are much too low", *Journal of Portfolio Management* 23(4), 104-111

Jagannathan, R. and Wang, Z., 1996, "The conditional CAPM and the cross-section of expected returns, *Journal of Finance* 51, 3-53

Kan, R. and Zhang, C., 1999, "Two-pass tests of asset pricing models with useless factors", *Journal of Finance* 54, 203-225

Kaplan, P. and J. Peterson, 1998, "Full-Information Industry betas," *Financial Management* 27(2), 85-93

Karels, G.V. and Sackley, W.H., 1993, "The Relationship Between Market and Accounting Betas for Commercial Banks", *Review of Financial Economics* 2, 59-72

Kim, D., 1993, "The extent of non-stationarity of beta", *Review of Quantitative Finance and Accounting* 3, 241-254

Kim, D., 1995, "The errors in the variables problem in the cross-section of expected stock returns", *Journal of Finance* 50, 1605-1634

Kim, M.K. and Zumwalt, J.K., 1979, "An analysis of risk in bull and bear markets", *Journal of Financial and Quantitative Analysis* 14, 1015-1025

Kothari, S.P., Shanken, J. and Sloan, R.G., 1995, "Another look at the cross-section of expected stock returns, *Journal of Finance* 50, 185-224

Kraus, A. and Litzenberger, R.H., 1976, "Skewness preference and the valuation of risky assets", *Journal of Finance* 31, 1085-1100

Kulkarni, M., Powers, M. and Shannon, D., 1991, "The Use of Segment Earnings Betas in the Formation of Divisional Hurdle Rates", *Journal of Business Finance and Accounting* 18(4), 497-511

Lewis-Beck, M., 1993, *Regression Analysis*, Sage Publications, London

Lintner, J., 1965, "The valuation of risky assets and the selection of risky investment in stock portfolios and capital budgets", *Review of Economics and Statistics* 47, 13-37

Miller, M. and Scholes, M., 1972, "Rates of return in relation to risk: a re-examination of some recent findings", *Studies in the Theory of Capital Markets,* Praeger, New York, 47-78

Modigliani, F. and Miller, M., 1958, "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review*, June 1958

Natale, F. P., 2005, "Estimating the Cost of Equity Capital for European Non-Life Insurance Companies", Conference Paper, European Financial Management Association

Park, K.W., 2004, "Time-series analysis of return and beta in the U.S.", *Journal of the Academy of Business and Economics* 1

Pettengill, G.N., Sundaram, S. and Mathur, L., 1995, "The conditional relation between beta and returns", *Journal of Financial and Quantitative Analysis* 30, 101-116

Pöyry Capital, 2000, Pulp and paper industry index

RISI, 2006, *Pulp & Paper International* September 2006, 15-22

Roll, R., 1977, "A critique of the asset pricing theory's tests; part I: on past and potential testability of the theory", *Journal of Financial Economics* 4, 129-176

Roll, R. and Ross, S.A., 1994, "On the cross-sectional relation between expected returns and betas", *Journal of Finance* 49, 101-121

Scholes, M. and Williams, J., 1977, "Estimating Beta from Nonsynchronous Data", *Journal of Financial Economics* 5(3), 309-327

Schwert, G.W., 1989, "Why does stock market volatility change over time?", *Journal of Finance* 44, 1115-1153

Sears, R.S. and Wei, K.C.J., 1985, "Asset pricing, higher moments, and the market risk premium: a note", *Journal of Finance* 40, 1251-1253

Stremme, A. and Basu, D., 2007, "CAPM and Time-Varying Beta: The Cross-Section of Expected Returns", Working Paper, Warwick Business School and City University of London

Tabachnick, B. G. and Fidell L. S., 2001, *Using Multivariate Statistics*, 4th Edition, Allyn and Bacon

Wang, X., "Size effect, book-to-market effect, and survival", 2000, *Journal of Multinational Financial Management* 10(3-4), 257-273

APPENDIX

Table 16
Regression of market cap. on beta

	Coef.	Sig.
Intercept	1,011822	0,00
Market cap.	-0,000005	0,64
R^2	0,01	
n	47	

Note: The table presents the result of a simple regression of market capitalization on beta for the 1998-2006 sample. Sig. denotes significance.

Table 17
T-Test: difference of sum-beta and normal beta

	Sum-beta	Normal
Mean	1,11	1,14
Variance	0,38	0,40
Observations	54	54
Pearson Correlation	0,90	
Hypothesized Mean Difference	0,00	
df	53	
t Stat	-0,82	
P(T<=t) one-tail	0,21	
t Critical one-tail	1,67	
P(T<=t) two-tail	0,42	
t Critical two-tail	2,01	

Note: The table reports results for a paired two sample t-test for the means of betas calculated with and without the sum-beta adjustment for the 2003-2006 sample.

Table 18
Product line share of Assets 1998-2002

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0 %	33 %	26 %	0 %	16 %	24 %	100 %
Stora Enso Oyj	4 %	61 %	20 %	0 %	4 %	11 %	100 %
Svenska Cellulosa AB	0 %	8 %	24 %	32 %	20 %	16 %	100 %
Procter & Gamble Company	0 %	0 %	0 %	37 %	0 %	63 %	100 %
Georgia Pacific	0 %	10 %	10 %	67 %	10 %	3 %	100 %
Kimberly-Clark Corp.	0 %	85 %	8 %	0 %	7 %	0 %	100 %
UPM-Kymmene Corp.	0 %	0 %	0 %	100 %	0 %	0 %	100 %
Weyerhaeuser Company Limited	12 %	21 %	12 %	0 %	24 %	32 %	100 %
Smurfit-Stone Container Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
M-Real Corp.	6 %	58 %	14 %	7 %	0 %	14 %	100 %
Paperlinx Limited	0 %	40 %	13 %	0 %	0 %	47 %	100 %
Meadwestvaco Corp.	0 %	28 %	64 %	0 %	0 %	9 %	100 %
Amcor Limited	0 %	0 %	40 %	0 %	0 %	60 %	100 %
Sappi Limited	0 %	85 %	0 %	0 %	15 %	0 %	100 %
Abitibi-Consolidated Inc	0 %	89 %	0 %	0 %	11 %	0 %	100 %
Norske Skogindustrier	3 %	97 %	0 %	0 %	0 %	0 %	100 %
Domtar Inc	0 %	74 %	12 %	0 %	12 %	3 %	100 %
Rengo Company Limited	0 %	0 %	85 %	0 %	0 %	15 %	100 %
Bowater Inc	0 %	61 %	0 %	0 %	27 %	12 %	100 %
Cascades Inc	0 %	12 %	55 %	15 %	0 %	17 %	100 %
Temple Inland Inc	0 %	0 %	10 %	0 %	7 %	83 %	100 %
Empresas CMPC SA	43 %	32 %	11 %	13 %	0 %	1 %	100 %
Tembec Inc	45 %	18 %	8 %	0 %	23 %	6 %	100 %
Mayr-Melnhof Karton AG	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Holmen AB	0 %	39 %	21 %	0 %	2 %	38 %	100 %
Rock Tenn	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Smith (DS) PLC	0 %	0 %	68 %	0 %	0 %	32 %	100 %
Catalyst Paper Corp.	35 %	29 %	0 %	0 %	0 %	35 %	100 %
Aracruz Celulose SA	100 %	0 %	0 %	0 %	0 %	0 %	100 %
Portucel Empresa	35 %	43 %	0 %	0 %	17 %	5 %	100 %
Nampak Limited	0 %	0 %	41 %	0 %	0 %	59 %	100 %
Suzano Papel E Celulose SA	1 %	68 %	30 %	0 %	0 %	0 %	100 %
Votorantim Celulose Papel SA	63 %	37 %	0 %	0 %	0 %	0 %	100 %
Wausau Paper Corp.	0 %	35 %	0 %	21 %	0 %	44 %	100 %
Potlatch Corp.	0 %	14 %	37 %	6 %	17 %	26 %	100 %
West Fraser Timber	0 %	0 %	0 %	0 %	50 %	50 %	100 %
Caraustar Industries	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Canfor	32 %	0 %	15 %	0 %	48 %	6 %	100 %
Longview Fibre Company	0 %	0 %	79 %	0 %	21 %	0 %	100 %
Cheng Loong Company Limited	0 %	13 %	65 %	0 %	0 %	23 %	100 %
Mercer International Inc	89 %	11 %	0 %	0 %	0 %	0 %	100 %
Gascogne	0 %	0 %	53 %	0 %	28 %	19 %	100 %
Greif Inc	0 %	0 %	44 %	0 %	3 %	53 %	100 %
Grupo Empresarial ENCE	85 %	0 %	0 %	0 %	6 %	9 %	100 %
Otor	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Pope & Talbot Inc	75 %	0 %	0 %	0 %	25 %	0 %	100 %
Rottneros	95 %	0 %	0 %	0 %	5 %	0 %	100 %
Average	15 %	23 %	29 %	6 %	8 %	17 %	100 %
							Total
Count of product-lines	16	26	31	9	23	30	135
Number of pure-player firms	1	0	5	1	0	0	7

Note: The table presents the product-line share of assets for the period 1998-2002 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 19

Product line share of Assets 2003-2006

Company	**Pulp**	**White**	**Packaging**	**Tissue**	**Wood prod.**	Other	Total
International Paper Company	0 %	44 %	34 %	0 %	10 %	11 %	100 %
Stora Enso Oyj	0 %	60 %	24 %	0 %	7 %	9 %	100 %
Svenska Cellulosa AB	0 %	7 %	29 %	44 %	20 %	0 %	100 %
Procter & Gamble Company	0 %	0 %	0 %	22 %	0 %	78 %	100 %
Georgia Pacific	0 %	7 %	11 %	70 %	11 %	0 %	100 %
Kimberly-Clark Corp.	0 %	0 %	0 %	100 %	0 %	0 %	100 %
UPM-Kymmene Corp.	0 %	87 %	6 %	0 %	7 %	0 %	100 %
Weyerhaeuser Company Limited	10 %	16 %	22 %	0 %	18 %	33 %	100 %
Smurfit-Stone Container Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
M-Real Corp.	0 %	70 %	20 %	0 %	0 %	10 %	100 %
Paperlinx Limited	0 %	20 %	8 %	0 %	0 %	73 %	100 %
Meadwestvaco Corp.	0 %	0 %	60 %	0 %	0 %	40 %	100 %
Amcor Limited	0 %	0 %	35 %	0 %	0 %	65 %	100 %
Sappi Limited	0 %	72 %	0 %	0 %	28 %	0 %	100 %
Abitibi-Consolidated Inc	0 %	90 %	0 %	0 %	10 %	0 %	100 %
Norske Skogindustrier	0 %	98 %	0 %	0 %	0 %	2 %	100 %
Domtar Inc	0 %	85 %	0 %	0 %	11 %	3 %	100 %
Rengo Company Limited	0 %	0 %	87 %	0 %	0 %	13 %	100 %
Bowater Inc	14 %	58 %	0 %	0 %	16 %	12 %	100 %
Cascades Inc	0 %	12 %	56 %	19 %	0 %	13 %	100 %
Temple Inland Inc	0 %	0 %	11 %	0 %	5 %	84 %	100 %
Sonoco Products Company	0 %	0 %	82 %	0 %	0 %	18 %	100 %
Graphic Packaging Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Empresas CMPC SA	30 %	25 %	10 %	19 %	0 %	16 %	100 %
Packaging Corp. Of America	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Tembec Inc	41 %	28 %	0 %	0 %	24 %	7 %	100 %
Mayr-Melnhof Karton AG	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Holmen AB	0 %	41 %	16 %	0 %	1 %	42 %	100 %
Rock Tenn	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Smith (DS) PLC	0 %	0 %	70 %	0 %	0 %	30 %	100 %
Catalyst Paper Corp.	21 %	28 %	0 %	0 %	0 %	51 %	100 %
Aracruz Celulose SA	100 %	0 %	0 %	0 %	0 %	0 %	100 %
Portucel Empresa	39 %	48 %	0 %	0 %	12 %	1 %	100 %
Nampak Limited	0 %	0 %	45 %	0 %	0 %	55 %	100 %
Suzano Papel E Celulose SA	25 %	58 %	17 %	0 %	0 %	0 %	100 %
Votorantim Celulose Papel SA	69 %	31 %	0 %	0 %	0 %	0 %	100 %
Klabin SA	0 %	0 %	88 %	0 %	0 %	12 %	100 %
Wausau Paper Corp.	0 %	34 %	0 %	22 %	0 %	43 %	100 %
Billerud AB	19 %	0 %	81 %	0 %	0 %	0 %	100 %
Potlatch Corp.	0 %	0 %	31 %	20 %	14 %	34 %	100 %
West Fraser Timber	0 %	0 %	0 %	0 %	66 %	34 %	100 %
Caraustar Industries	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Canfor	34 %	0 %	0 %	0 %	66 %	0 %	100 %
Longview Fibre Company	0 %	0 %	78 %	0 %	22 %	0 %	100 %
Cheng Loong Company Limited	0 %	14 %	69 %	0 %	0 %	16 %	100 %
Mercer International Inc	98 %	2 %	0 %	0 %	0 %	0 %	100 %
Gascogne	0 %	0 %	55 %	0 %	23 %	22 %	100 %
Greif Inc	0 %	0 %	18 %	0 %	0 %	82 %	100 %
VPK Packaging	0 %	0 %	97 %	0 %	0 %	3 %	100 %
Grupo Empresarial ENCE	39 %	0 %	0 %	0 %	61 %	0 %	100 %
Otor	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Pope & Talbot Inc	76 %	0 %	0 %	0 %	24 %	0 %	100 %
Rottneros	98 %	0 %	0 %	0 %	2 %	0 %	100 %
Neenah Paper	55 %	19 %	0 %	0 %	0 %	26 %	100 %
Average	14 %	20 %	34 %	6 %	9 %	17 %	100 %
							Total
Count of product-lines	16	25	34	8	22	31	136
Number of pure-player firms	1	0	7	1	0	0	9

Note: The table presents the product-line share of assets for the period 2003-2006 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 20
Product line share of Assets 1998-2006

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0 %	39 %	30 %	0 %	13 %	18 %	100 %
Stora Enso Oyj	2 %	60 %	22 %	0 %	5 %	10 %	100 %
Svenska Cellulosa AB	0 %	8 %	27 %	38 %	20 %	8 %	100 %
Procter & Gamble Company	0 %	0 %	0 %	30 %	0 %	70 %	100 %
Georgia Pacific	0 %	8 %	11 %	69 %	11 %	2 %	100 %
Kimberly-Clark Corp.	0 %	0 %	0 %	100 %	0 %	0 %	100 %
UPM-Kymmene Corp.	0 %	86 %	7 %	0 %	7 %	0 %	100 %
Weyerhaeuser Company Limited	11 %	18 %	17 %	0 %	21 %	32 %	100 %
Smurfit-Stone Container Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
M-Real Corp.	3 %	64 %	17 %	3 %	0 %	12 %	100 %
Paperlinx Limited	0 %	30 %	11 %	0 %	0 %	60 %	100 %
Meadwestvaco Corp.	0 %	14 %	62 %	0 %	0 %	24 %	100 %
Amcor Limited	0 %	0 %	37 %	0 %	0 %	63 %	100 %
Sappi Limited	0 %	78 %	0 %	0 %	22 %	0 %	100 %
Abitibi-Consolidated Inc	0 %	89 %	0 %	0 %	11 %	0 %	100 %
Norske Skogindustrier	1 %	98 %	0 %	0 %	0 %	1 %	100 %
Domtar Inc	0 %	80 %	6 %	0 %	11 %	3 %	100 %
Rengo Company Limited	0 %	0 %	86 %	0 %	0 %	14 %	100 %
Bowater Inc	7 %	60 %	0 %	0 %	21 %	12 %	100 %
Cascades Inc	0 %	12 %	56 %	17 %	0 %	15 %	100 %
Temple Inland Inc	0 %	0 %	11 %	0 %	6 %	84 %	100 %
Empresas CMPC SA	36 %	28 %	11 %	16 %	0 %	9 %	100 %
Tembec Inc	43 %	23 %	4 %	0 %	23 %	6 %	100 %
Mayr-Melnhof Karton AG	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Holmen AB	0 %	40 %	19 %	0 %	1 %	40 %	100 %
Rock Tenn	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Smith (DS) PLC	0 %	0 %	69 %	0 %	0 %	31 %	100 %
Catalyst Paper Corp.	28 %	29 %	0 %	0 %	0 %	43 %	100 %
Aracruz Celulose SA	100 %	0 %	0 %	0 %	0 %	0 %	100 %
Portucel Empresa	37 %	45 %	0 %	0 %	14 %	3 %	100 %
Nampak Limited	0 %	0 %	43 %	0 %	0 %	57 %	100 %
Suzano Papel E Celulose SA	13 %	63 %	24 %	0 %	0 %	0 %	100 %
Votorantim Celulose Papel SA	66 %	34 %	0 %	0 %	0 %	0 %	100 %
Wausau Paper Corp.	0 %	35 %	0 %	22 %	0 %	44 %	100 %
Potlatch Corp.	0 %	7 %	34 %	13 %	16 %	30 %	100 %
West Fraser Timber	0 %	0 %	0 %	0 %	58 %	42 %	100 %
Caraustar Industries	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Canfor	33 %	0 %	7 %	0 %	57 %	3 %	100 %
Longview Fibre Company	0 %	0 %	78 %	0 %	22 %	0 %	100 %
Cheng Loong Company Limited	0 %	13 %	67 %	0 %	0 %	19 %	100 %
Mercer International Inc	94 %	6 %	0 %	0 %	0 %	0 %	100 %
Gascogne	0 %	0 %	54 %	0 %	26 %	20 %	100 %
Greif Inc	0 %	0 %	31 %	0 %	1 %	68 %	100 %
Grupo Empresarial ENCE	62 %	0 %	0 %	0 %	34 %	4 %	100 %
Otor	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Pope & Talbot Inc	76 %	0 %	0 %	0 %	24 %	0 %	100 %
Rottneros	96 %	0 %	0 %	0 %	4 %	0 %	100 %
Average	15 %	23 %	29 %	7 %	9 %	18 %	100 %
							Total
Count of product-lines	17	26	31	9	23	31	137
Number of pure-player firms	1	0	5	1	0	0	7

Note: The table presents the product-line share of assets for the period 1998-2006 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 21
Product line share of Sales 1998-2002

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0 %	25 %	24 %	0 %	10 %	41 %	100 %
Stora Enso Oyj	3 %	51 %	19 %	0 %	8 %	19 %	100 %
Svenska Cellulosa AB	0 %	16 %	32 %	45 %	7 %	0 %	100 %
Procter & Gamble Company	0 %	0 %	0 %	28 %	0 %	72 %	100 %
Georgia Pacific	0 %	14 %	11 %	15 %	25 %	35 %	100 %
Kimberly-Clark Corp.	0 %	0 %	0 %	100 %	0 %	0 %	100 %
UPM-Kymmene Corp.	0 %	66 %	15 %	0 %	15 %	4 %	100 %
Weyerhaeuser Company Limited	9 %	16 %	13 %	0 %	42 %	21 %	100 %
Smurfit-Stone Container Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
M-Real Corp.	8 %	45 %	18 %	10 %	0 %	20 %	100 %
Paperlinx Limited	0 %	29 %	11 %	0 %	0 %	60 %	100 %
Meadwestvaco Corp.	0 %	27 %	56 %	0 %	0 %	17 %	100 %
Amcor Limited	0 %	0 %	40 %	0 %	0 %	60 %	100 %
Sappi Limited	0 %	78 %	0 %	0 %	22 %	0 %	100 %
Abitibi-Consolidated Inc	0 %	84 %	0 %	0 %	16 %	0 %	100 %
Norske Skogindustrier	7 %	93 %	0 %	0 %	0 %	0 %	100 %
Domtar Inc	0 %	60 %	14 %	0 %	14 %	13 %	100 %
Rengo Company Limited	0 %	0 %	85 %	0 %	0 %	15 %	100 %
Bowater Inc	0 %	55 %	0 %	0 %	25 %	20 %	100 %
Cascades Inc	0 %	25 %	46 %	14 %	0 %	15 %	100 %
Temple Inland Inc	0 %	0 %	51 %	0 %	19 %	29 %	100 %
Empresas CMPC SA	43 %	32 %	11 %	13 %	0 %	1 %	100 %
Tembec Inc	37 %	21 %	6 %	0 %	33 %	3 %	100 %
Mayr-Melnhof Karton AG	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Holmen AB	0 %	46 %	26 %	0 %	4 %	24 %	100 %
Rock Tenn	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Smith (DS) PLC	0 %	0 %	51 %	0 %	0 %	49 %	100 %
Catalyst Paper Corp.	28 %	30 %	0 %	0 %	0 %	41 %	100 %
Aracruz Celulose SA	100 %	0 %	0 %	0 %	0 %	0 %	100 %
Portucel Empresa	33 %	61 %	0 %	0 %	1 %	4 %	100 %
Nampak Limited	0 %	0 %	36 %	0 %	0 %	64 %	100 %
Suzano Papel E Celulose SA	1 %	68 %	30 %	0 %	0 %	0 %	100 %
Votorantim Celulose Papel SA	40 %	60 %	0 %	0 %	0 %	0 %	100 %
Wausau Paper Corp.	0 %	41 %	0 %	19 %	0 %	41 %	100 %
Potlatch Corp.	0 %	9 %	32 %	8 %	27 %	24 %	100 %
West Fraser Timber	0 %	0 %	0 %	0 %	58 %	42 %	100 %
Caraustar Industries	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Canfor	19 %	0 %	10 %	0 %	62 %	9 %	100 %
Longview Fibre Company	0 %	0 %	80 %	0 %	20 %	0 %	100 %
Cheng Loong Company Limited	0 %	21 %	75 %	0 %	0 %	4 %	100 %
Mercer International Inc	54 %	46 %	0 %	0 %	0 %	0 %	100 %
Gascogne	0 %	0 %	41 %	0 %	41 %	18 %	100 %
Greif Inc	0 %	0 %	35 %	0 %	3 %	62 %	100 %
Grupo Empresarial ENCE	85 %	0 %	0 %	0 %	6 %	9 %	100 %
Otor	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Pope & Talbot Inc	55 %	0 %	0 %	0 %	45 %	0 %	100 %
Rottneros	95 %	0 %	0 %	0 %	5 %	0 %	100 %
Average	13 %	24 %	29 %	5 %	11 %	18 %	100 %
							Total
Count of product-lines	16	26	31	9	23	31	136
Number of pure-player firms	1	0	5	1	0	0	7

Note: The table presents the product-line share of sales for the period 1998-2002 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 22
Product line share of Sales 2003-2006

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0 %	32 %	31 %	0 %	5 %	32 %	100 %
Stora Enso Oyj	0 %	48 %	20 %	0 %	10 %	22 %	100 %
Svenska Cellulosa AB	0 %	9 %	34 %	47 %	10 %	0 %	100 %
Procter & Gamble Company	0 %	0 %	0 %	20 %	0 %	80 %	100 %
Georgia Pacific	0 %	10 %	13 %	34 %	29 %	14 %	100 %
Kimberly-Clark Corp.	0 %	0 %	0 %	100 %	0 %	0 %	100 %
UPM-Kymmene Corp.	0 %	71 %	14 %	0 %	15 %	0 %	100 %
Weyerhaeuser Company Limited	7 %	10 %	20 %	0 %	39 %	13 %	88 %
Smurfit-Stone Container Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
M-Real Corp.	0 %	56 %	18 %	0 %	0 %	26 %	100 %
Paperlinx Limited	0 %	12 %	4 %	0 %	0 %	84 %	100 %
Meadwestvaco Corp.	0 %	0 %	53 %	0 %	0 %	47 %	100 %
Amcor Limited	0 %	0 %	31 %	0 %	0 %	69 %	100 %
Sappi Limited	0 %	76 %	0 %	0 %	24 %	0 %	100 %
Abitibi-Consolidated Inc	0 %	84 %	0 %	0 %	16 %	0 %	100 %
Norske Skogindustrier	0 %	91 %	0 %	0 %	0 %	9 %	100 %
Domtar Inc	0 %	64 %	0 %	0 %	13 %	23 %	100 %
Rengo Company Limited	0 %	0 %	83 %	0 %	0 %	17 %	100 %
Bowater Inc	16 %	59 %	0 %	0 %	11 %	14 %	100 %
Cascades Inc	0 %	20 %	49 %	19 %	0 %	12 %	100 %
Temple Inland Inc	0 %	0 %	56 %	0 %	20 %	24 %	100 %
Sonoco Products Company	0 %	0 %	79 %	0 %	0 %	21 %	100 %
Graphic Packaging Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Empresas CMPC SA	30 %	25 %	10 %	19 %	0 %	16 %	100 %
Packaging Corp. Of America	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Tembec Inc	37 %	24 %	0 %	0 %	33 %	5 %	100 %
Mayr-Melnhof Karton AG	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Holmen AB	0 %	42 %	25 %	0 %	2 %	30 %	100 %
Rock Tenn	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Smith (DS) PLC	0 %	0 %	53 %	0 %	0 %	47 %	100 %
Catalyst Paper Corp.	24 %	28 %	0 %	0 %	0 %	48 %	100 %
Aracruz Celulose SA	100 %	0 %	0 %	0 %	0 %	0 %	100 %
Portucel Empresa	37 %	46 %	0 %	0 %	7 %	10 %	100 %
Nampak Limited	0 %	0 %	47 %	0 %	0 %	53 %	100 %
Suzano Papel E Celulose SA	25 %	58 %	17 %	0 %	0 %	0 %	100 %
Votorantim Celulose Papel SA	36 %	64 %	0 %	0 %	0 %	0 %	100 %
Klabin SA	0 %	0 %	88 %	0 %	0 %	12 %	100 %
Wausau Paper Corp.	0 %	36 %	0 %	23 %	0 %	41 %	100 %
Billerud AB	19 %	0 %	81 %	0 %	0 %	0 %	100 %
Potlatch Corp.	0 %	0 %	32 %	20 %	26 %	22 %	100 %
West Fraser Timber	0 %	0 %	0 %	0 %	71 %	29 %	100 %
Caraustar Industries	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Canfor	25 %	0 %	0 %	0 %	75 %	0 %	100 %
Longview Fibre Company	0 %	0 %	79 %	0 %	21 %	0 %	100 %
Cheng Loong Company Limited	0 %	20 %	73 %	0 %	0 %	7 %	100 %
Mercer International Inc	78 %	22 %	0 %	0 %	0 %	0 %	100 %
Gascogne	0 %	0 %	52 %	0 %	28 %	20 %	100 %
Greif Inc	0 %	0 %	26 %	0 %	0 %	74 %	100 %
VPK Packaging	0 %	0 %	92 %	0 %	0 %	8 %	100 %
Grupo Empresarial ENCE	76 %	0 %	0 %	0 %	24 %	0 %	100 %
Otor	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Pope & Talbot Inc	57 %	0 %	0 %	0 %	43 %	0 %	100 %
Rottneros	98 %	0 %	0 %	0 %	2 %	0 %	100 %
Neenah Paper	39 %	37 %	0 %	0 %	0 %	24 %	100 %
Average	13 %	19 %	35 %	5 %	10 %	18 %	100 %
							Total
Count of product-lines	16	25	34	8	22	32	137
Number of pure-player firms	1	0	7	1	0	0	9

Note: The table presents the product-line share of sales for the period 2003-2006 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.

Table 23
Product line share of Sales 1998-2006

Company	Pulp	White	Packaging	Tissue	Wood prod.	Other	Total
International Paper Company	0 %	28 %	28 %	0 %	8 %	37 %	100 %
Stora Enso Oyj	1 %	50 %	20 %	0 %	9 %	20 %	100 %
Svenska Cellulosa AB	0 %	12 %	33 %	46 %	9 %	0 %	100 %
Procter & Gamble Company	0 %	0 %	0 %	24 %	0 %	76 %	100 %
Georgia Pacific	0 %	12 %	12 %	25 %	27 %	24 %	100 %
Kimberly-Clark Corp.	0 %	0 %	0 %	100 %	0 %	0 %	100 %
UPM-Kymmene Corp.	0 %	69 %	14 %	0 %	15 %	2 %	100 %
Weyerhaeuser Company Limited	8 %	13 %	16 %	0 %	40 %	17 %	94 %
Smurfit-Stone Container Corp.	0 %	0 %	100 %	0 %	0 %	0 %	100 %
M-Real Corp.	4 %	50 %	18 %	5 %	0 %	23 %	100 %
Paperlinx Limited	0 %	20 %	8 %	0 %	0 %	72 %	100 %
Meadwestvaco Corp.	0 %	13 %	55 %	0 %	0 %	32 %	100 %
Amcor Limited	0 %	0 %	36 %	0 %	0 %	64 %	100 %
Sappi Limited	0 %	77 %	0 %	0 %	23 %	0 %	100 %
Abitibi-Consolidated Inc	0 %	84 %	0 %	0 %	16 %	0 %	100 %
Norske Skogindustrier	4 %	92 %	0 %	0 %	0 %	4 %	100 %
Domtar Inc	0 %	62 %	7 %	0 %	14 %	18 %	100 %
Rengo Company Limited	0 %	0 %	84 %	0 %	0 %	16 %	100 %
Bowater Inc	8 %	57 %	0 %	0 %	18 %	17 %	100 %
Cascades Inc	0 %	23 %	47 %	16 %	0 %	14 %	100 %
Temple Inland Inc	0 %	0 %	54 %	0 %	20 %	27 %	100 %
Empresas CMPC SA	36 %	28 %	11 %	16 %	0 %	9 %	100 %
Tembec Inc	37 %	23 %	3 %	0 %	33 %	4 %	100 %
Mayr-Melnhof Karton AG	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Holmen AB	0 %	44 %	25 %	0 %	3 %	27 %	100 %
Rock Tenn	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Smith (DS) PLC	0 %	0 %	52 %	0 %	0 %	48 %	100 %
Catalyst Paper Corp.	26 %	29 %	0 %	0 %	0 %	45 %	100 %
Aracruz Celulose SA	100 %	0 %	0 %	0 %	0 %	0 %	100 %
Portucel Empresa	35 %	54 %	0 %	0 %	4 %	7 %	100 %
Nampak Limited	0 %	0 %	41 %	0 %	0 %	59 %	100 %
Suzano Papel E Celulose SA	13 %	63 %	24 %	0 %	0 %	0 %	100 %
Votorantim Celulose Papel SA	38 %	62 %	0 %	0 %	0 %	0 %	100 %
Wausau Paper Corp.	0 %	39 %	0 %	21 %	0 %	41 %	100 %
Potlatch Corp.	0 %	4 %	32 %	14 %	27 %	23 %	100 %
West Fraser Timber	0 %	0 %	0 %	0 %	65 %	35 %	100 %
Caraustar Industries	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Canfor	22 %	0 %	5 %	0 %	68 %	5 %	100 %
Longview Fibre Company	0 %	0 %	79 %	0 %	21 %	0 %	100 %
Cheng Loong Company Limited	0 %	20 %	74 %	0 %	0 %	6 %	100 %
Mercer International Inc	66 %	34 %	0 %	0 %	0 %	0 %	100 %
Gascogne	0 %	0 %	46 %	0 %	35 %	19 %	100 %
Greif Inc	0 %	0 %	30 %	0 %	1 %	68 %	100 %
Grupo Empresarial ENCE	80 %	0 %	0 %	0 %	15 %	4 %	100 %
Otor	0 %	0 %	100 %	0 %	0 %	0 %	100 %
Pope & Talbot Inc	56 %	0 %	0 %	0 %	44 %	0 %	100 %
Rottneros	96 %	0 %	0 %	0 %	4 %	0 %	100 %
Average	13 %	23 %	29 %	6 %	11 %	18 %	100 %
							Total
Count of product-lines	17	26	31	9	23	31	137
Number of pure-player firms	1	0	5	1	0	0	7

Note: The table presents the product-line share of sales for the period 1998-2006 based on the segment reports of the companies. Divisions are aggregated to each product-line according to the defined classification scheme: e.g. if a firm has both a newspaper and a magazine paper division, their share is added together under 'White' and this accounts for one product-line in the summary at the bottom of the table. A 'pure-player' is a firm that has 100% of its share in a single product-line.